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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

E. F. PITTMAN, A.R.S.M., GOVERNMENT GEOLOGIST.

HANDBOOK

TO THE

MINING AND GEOLOGICAL MUSEUM,

SYDNEY.

BY

GEORGE W. CARD, A.R.S.M., F.G.S.,

CURATOR AND MINERALOGIST.

WITH SPECIAL REFERENCES TO THE MINERALOGICAL COLLECTIONS



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PLATE I.



THE MINING AND GEOLOGICAL MUSEUM.

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LETTER OF TRANSMITTAL.

Geological Survey Branch,
Department of Mines,
Sydney, 9 January, 1902.

Sir,

I have the honor to submit for publication a "Handbook to the Mining and Geological Museum," prepared by Mr. George W. Card, A.R.S.M., F.G.S., Mineralogist and Curator.

The collection of rocks, fossils, and minerals for the Geological Survey Museum was started in the year 1875 by the late Mr. C. S. Wilkinson, Geological Surveyor-in-charge, and rapidly increased in magnitude after the appointment of the Geological Survey Staff in the year 1878.

In 1879 the collection contained 14,720 specimens, and towards the latter end of the same year it was largely increased by the addition of the late Rev. W. B. Clarke's private collection, which, together with his library, was purchased by the Government.

On the closing of the Sydney Exhibition in 1880, the Geological Survey Museum was installed in the "Garden Palace," or Exhibition Building, a large wooden structure in the Inner Domain, but unfortunately, on the 22nd September, 1882, this edifice was totally destroyed by fire, and thus an exceedingly valuable collection, numbering upwards of 50,000 specimens, was lost.

The work of renewing the collection was at once proceeded with by the late Mr. Wilkinson, and has been zealously continued ever since. The Museum now contains a valuable and representative collection of the rocks, minerals, and fossils of New South Wales, and is of considerable use to students of geology and others who take an interest in the mineral resources of the State.

The chief requirement at present is a good Museum building the one now in use being of a temporary character, and very unsuitable for the display of such valuable specimens. Moreover until a more modern structure is provided there will always be a risk of the collection being lost a second time through fire.

I have the honor to be,

Sir,

Your obedient servant,

E. F. PITTMAN.

Government Geologist

The Under Secretary for Mines,
Sydney.

INTRODUCTION.

THIS Handbook has been prepared primarily in the hope that it may be useful to persons visiting the Mining and Geological Museum. It deals principally with the mineralogical collections and ore occurrences; separate publications, dealing in detail with the rocks and fossils, are in preparation.

While not containing much that is new, the collections described are so comprehensive that this work will perhaps prove of some assistance to students desiring to obtain a knowledge of the Mineralogy of New South Wales.

Explanatory Notes are scattered through the text, but the frequent custom of including a few chapters on Mineralogy and Crystallography has not been followed. This information can be much better obtained from the admirable little text-books that are now everywhere procurable.



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OFFICE.

WORK-ROOMS.



*Photo-lithographed by
W. A. Gullick, Government Printer,
Sydney, N.S.W.*

HISTORY AND OBJECTS OF THE MINING AND GEOLOGICAL MUSEUM.

THE Mining and Geological Museum has been practically History. co-existent with the Department of Mines. The charge of the Museum is one of the duties of the Mineralogist attached to the Geological Survey, who is responsible to the Government Geologist. The Museum is open, free, between the hours of 10 a.m. and 4 p.m. on every day of the year, other than Sundays, Christmas Day, and Good Friday.

The institution first occupied premises in Young-street, Sydney, and was opened to the public on 6th March, 1876. In 1881 the collections were removed to the Exhibition Buildings in the Inner Domain, and, when just ready for opening, were entirely consumed in the Garden Palace fire on September 22, 1882. Some fifty thousand specimens, including most of the Rev. W. B. Clarke's invaluable collections, library, and manuscripts, were lost. A small temporary structure having been erected at the back of the Geological Survey offices, 233, Macquarie-street, the nucleus of a new collection was got together and opened to the public in 1886. Up to this time, and till the end of 1892, the Museum was under the care of Mr. J. E. Carne, F.G.S., to whose enthusiasm much of the success of the institution is due. In 1893 an opportunity of obtaining the more commodious premises now occupied was afforded by the removal of the Technological Museum collections from the galvanized-iron building, formerly used in connection with the Sydney Exhibition, situated in the Inner Domain, at the back of the Sydney Hospital. The accommodation provided is, however, still inadequate. An area of about 5750 square feet was partitioned off for a Public Museum, the remainder of the building being required for work-rooms. The Museum was opened in May, 1894, by the Hon. T. Slattery, then Minister for Mines. Most of the collections are now registered, classified and neatly—if temporarily—labelled.

Object.

The purpose the Museum is intended to serve is a very distinct one—quite different from the functions of any other institution in Sydney. Primarily, the object is to illustrate the geology and mineral deposits of New South Wales; secondarily, to exhibit for comparison specimens bearing upon special ore-occurrences in other parts of the world. It may thus be compared with such institutions as the Museum of Practical Geology, London; the Mining Bureau Museum, San Francisco; the Canadian Museum, Ottawa; the Calcutta Museum; the Museum of the Chamber of Mines, Johannesburg; and others. A separate collection to illustrate Economic Geology on an extensive scale is now being undertaken by the Geological Survey of the United States, in connection with the National Museum, Washington.

General Arrangement.

The central floor-space is occupied by the general collection of metallic ores; those from New South Wales being arranged from right to left on the western, and those from other places arranged from left to right on the eastern, side of the building. The rock-forming minerals, whether from New South Wales or other localities, are placed together, immediately following the ores on the foreign side. The magnificent collection of fossils ranges round the building in stratigraphical order, beginning with the oldest. At the lower end of the room, in upright cases, are the building stones and lode, and other specimens of large size.

The ores which constitute the bulk of the collections are classified according to their metallic contents, the order being, in general, that followed in Rutley's Text-book.* An attempt is made to fully illustrate the mode of occurrence of the ores of the different metals, and the structure of each important mining district, by means of typical specimens of country-rock, ore, and associated minerals from different levels. The ores of any given metal are arranged geographically. From this it follows that a very subordinate position is assigned to chemical composition. By consistently following this plan, it is hoped to make the Museum of great value to the mining community.†

* Elements of Mineralogy, price two shillings.

† Difficulty is sometimes experienced in obtaining suitable material, as it is not readily understood that what is wanted is not so much picked specimens, or those that are considered oddities, as the ordinary ores, rocks, &c., which there is a tendency to neglect because they are common.

The geographical method will also be adhered to in arranging and describing the igneous rocks. For instance, all the rocks intrusive in the Hawkesbury series, and those characterising the New England tableland, will respectively be placed together, without regard to their classification as objects. The sedimentary rocks, like the fossils, are arranged according to their geological age.

The provision made for the special requirements of students is **Students.** at present limited. In two cases (33, 34), immediately to the right of the entrance, will be found specially arranged collections of minerals and of fossils respectively. The physical properties of minerals, such as *streak, hardness, form, &c.*, are illustrated by carefully chosen specimens; while the possibility of identifying certain minerals, such as *quartz, garnet, &c.*, by their crystalline form is similarly demonstrated.* No attempt is made to deal with Crystallography. The fossils comprise only those forms that are characteristic of the Sedimentary Formations of New South Wales, and are intended especially for mine managers and others who desire to recognise the fossiliferous formations they are working in without concerning themselves with zoological classification.† There is, further, at the disposal of students a series of typical minerals, rocks, and fossils, the first-mentioned following the order of Rutley's Text-book. To use these a student is required to make personal application for an admission ticket, on showing which the specimens can be freely examined and handled in the private portions of the building. It is hoped that the privilege will be acceptable to those who are not able to attend classes.

A beginning has been made with a collection of photographs **Geological Photographs.** illustrating the geology and mineralogy of the State. Duplicates of many of these have been mounted in a large album near the door, and others specially selected have been enlarged and framed. Enlargements are hung on the walls.

* Copies of the descriptive labels used will be found at the end of this Handbook.

† A list of the fossils selected will be found at the end of this Handbook.



MINERALS OF ECONOMIC VALUE, NEW SOUTH WALES.

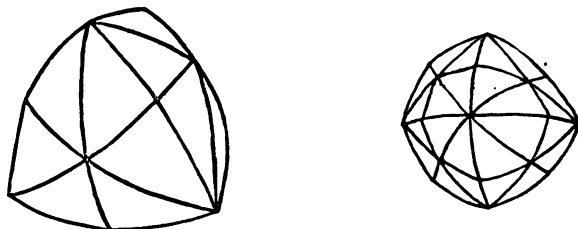
GEMSTONES.

[NOTE.—The collection of gemstones is by no means a satisfactory one, partly due to the Museum having suffered heavily from burglary.]

Crystallised carbon: As is well known, the diamond is characterised by its great hardness ($H=10$) and brilliancy. Crystals are characterised by curved faces. The most common crystalline form is that of an *octahedron*, on the faces of which low three-sided or six-sided pyramids are frequently built.*

Case 49.
Diamond.

The diamond sinks in heavy liquids.†



Diamond Crystals.

Diamonds have been found in numerous alluvial deposits in New South Wales, but in the vicinity of Bingera and of Inverell alone have the deposits as yet proved of any commercial importance. The stones are small in size, but of great hardness.

7363, 2291, 2292, respectively from Round Mount and Boggy Camp, Inverell, show diamonds still embedded in the alluvial washdirt.

* Clear quartz crystals are not infrequently mistaken for diamonds; their crystalline form is, however, so very different (page 132) that the distinction between them is easy. Moreover, quartz floats in heavy liquids.

† *Heavy Liquids*.—A number of liquids can be obtained of such a density as to permit certain minerals to float, in the same way as wood does in water; while others sink by reason of their greater density. This affords a most valuable means of distinguishing many minerals. Two of these heavy liquids that can be procured without difficulty, and used without risk, may be mentioned, viz., boro-tungstate of cadmium (known as Klein's Solution), and methylene iodide. Hornblende will float in either of these when the density is near its maximum.

Case 49. The numerous samples of diamantiferous wash are of interest. 9163, 7653, 9250, and others, represent the pebbles associated with the diamond. They comprise *sapphire*, *topaz*, *zircon*, *quartz* (often jasperoid), and, in particular, a description of black *tourmaline*, known as the pencil variety from its elongated form. This is well shown in 9163.

Like gold- and tin- bearing leads, the diamantiferous wash may be overlain by a flow of basalt. 7715, a cavernous basalt containing calcite, is such a flow from the Bingera field.*

9250, near Bendemeer: a twin crystal.

7318: A small greenish stone from near Gunning.

2128: Wash from near Mittagong, where a few stones were found, some years ago, in a small area of alluvial wash overlying the Hawkesbury Formation.

The original source of the diamonds found in the alluvial deposits of New South Wales, as in the case of the Indian and Brazilian fields, is not certainly known; but a recent discovery of eclogite at Ruby Hill, Bingera, appears to indicate the possibility of this crystalline rock having been the parent-rock there, as is believed to be the case in South Africa. It is probable that, were the true home of the diamond to be traced, the stones might be very sparsely scattered through it.

The occurrence in rocks of igneous origin at Kimberley and the possibility of artificially preparing diamonds throw much light as to their probable origin. The Kimberley occurrence is described on page 101. The following notes on the artificial preparation of diamonds will be of interest:—

A French chemist, M. Moissan, considering that enormous pressure would assist the crystallisation of carbon, made use of the property possessed by molten iron of expanding when it solidifies.† Moissan filled a very strong steel cylinder with molten cast-iron, and hermetically sealed it. Not being able to burst the cylinder, the expansive force of the solidifying iron squeezed the molecules closer together, and compelled some of the carbon—which is always present in cast-iron—to crystallise. On dissolving away the surrounding metal with powerful acids, minute diamonds were found among the residues.

A German chemist has produced diamonds by simply stirring molten *olivine*—a mineral found in many igneous rocks—with a rod of carbon.

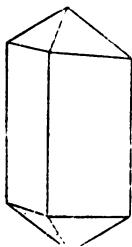
* There is no analogy, as is sometimes imagined, between this basalt cover and the igneous rock constituting the matrix of the Kimberley Diamond Field. (See page 101.)

† Water has the same property. An old experiment was to fill a bomb with water, plug up the opening, and place it in a freezing mixture; in freezing, the water expands, expelling the plug, or even bursting the bomb.

Oxide of aluminium, Al_2O_3 .* Sapphires are common enough in certain river-drifts in New England and elsewhere, where it is associated with *zircon*, *topaz*, &c., but it is seldom that stones suitable for jewellery are found. Several cut stones are exhibited. Next to the diamond, oxide of aluminium is the hardest substance found in Nature ($H=8$). The density is high (specific gravity about 4), so that it quickly sinks in heavy liquids. (See page 15.) Occasionally pebbles will be found showing something of the original crystalline form—a six-sided double pyramid when perfect, breaking by transverse cleavage into six-sided plates. A crystal of sapphire from Tumbarumba, showing a flat termination, will be found in **Students' case 33.**

Case 49.
Sapphire.

Silicate of zirconia: The gemstones *hyacinth* and *jargoon* are varieties of zircon. It is a hard mineral ($H=7.5$) of high density, with a lustre so brilliant that, when colourless, it may easily be mistaken for the diamond. It varies in colour from red-brown to colourless, but the colour is permanently destroyed by heating; a tray of stones thus rendered colourless is exhibited. Owing to its high density (nearly twice that of quartz) it cannot be readily separated from gold by panning, so that the gold in zircon sand cannot be freed by concentration. Zircon is common in many drift deposits. (See page 22.) When good crystals are found they can be readily recognised by their square sections (7635). Most commonly, however, zircon occurs as rounded grains.



Simple crystal of Zircon. *Prism with pyramid.*

* Oxide of aluminium, or alumina, in its common massive form, is known as *corundum*. (See page 154, and show case 99.)

Case 49.**Topaz.**

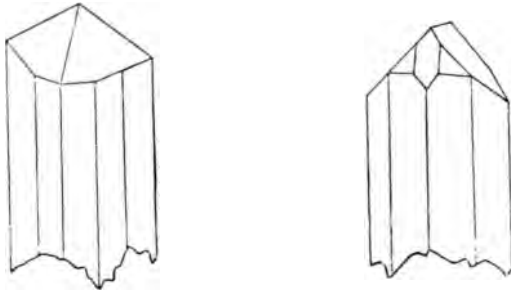
Silicate of alumina with fluoride of silicon: one of the few minerals that contain *fluorine*. When perfectly transparent, as it frequently is, topaz is a useful gemstone. It is very hard ($H=8$) scratching glass with ease. While generally colourless (9219) or of a yellowish tint, topaz is sometimes blue (8029 and others) or pink. As pebbles, it is common in many river-drifts, particularly those of New England (2317, 8029). The pebbles very much resemble quartz, but can be distinguished—

(a) by splitting with perfectly even cleavage-flakes; crystals purposely cleaved by tapping with a hammer are placed here.

(b) by greater density, topaz sinking rapidly in heavy liquids (see page 9.)

Crystals of topaz are not uncommon, and can be readily recognised by their characteristic form (9219, and a blue crystal, the faces of which have been marked with their crystallographic symbols). 2380, a large blue crystal from New England, shows the terminal faces of topaz well.

Like beryl, tourmaline, fluor, and tinstone, topaz generally originates in granitic rocks, and is frequently associated with those minerals. 9082 and others, from the Emmaville emerald mine, illustrate this. A few cut stones are exhibited.

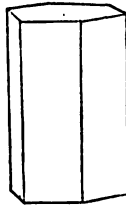


Crystals of Topaz.

Hydrated phosphate of alumina: Thin veins of turquoise occur **Case 49.** in an indurated slate near Bodalla. **5782** shows the mode of **Turquoise.** occurrence in veins. The deposit has not as yet proved of commercial value.

For turquoise from Victoria and Queensland, see **case 78**; and for other phosphates of alumina, **case 102.**

The gem variety of beryl: Silicate of alumina and berylla. **Emerald.** For beryl in general, see **case 100.** This mineral contains the rare element glucinium (beryllium). It is frequently associated with tinstone in New England (**7949, 1988, 1616, 7937, 5355,** in **case 64**), especially from The Gulf. It is one of the minerals (see above under **Topaz**) frequently found in granite. Emmaville is the only locality in New South Wales where emeralds of marketable quality have been found. The cut stones exhibited represent some of the best. It will be seen that the colour is rather pale. The mode of occurrence in granite is well shown by **6918, 2122, 2130.** The granite consists of cream-coloured felspar, with quartz, black mica, and tinstone, and contains well-formed emerald crystals embedded in it promiscuously. The six-sided prisms of beryl are very characteristic. **2122** shows several such, both longitudinally and in transverse section. Beryl is harder than quartz ($H \approx 8$) and will therefore scratch glass readily. The density is low, but it will generally sink in heavy liquids (see page 15) diluted so as to just permit quartz to float. Beryl never has the pyramidal terminations of quartz. A large block, showing several emeralds *in situ*, will be found in **case 128.**



Simple crystal of Beryl. *Prism with basal plane.*

PRECIOUS OPAL.

Case 48. PRECIOUS OPAL is obtained in considerable quantities, some of the very finest quality, at *White Cliffs*, to the north-north-west of Wilcannia. The opal is found in sedimentary rocks of Upper Cretaceous age. The district is covered by several feet of drift material, so that there are no surface indications of the existence of opal. The opal occurs in small pipes, veins, &c.

The exhibit is intended to illustrate the manner in which the opal occurs; and, although a number of cut stones are exhibited, there are none of very fine quality.

10110; Veins in ironstone.

The opal is frequently found replacing fossil organisms. Of these the following are noteworthy:—

10117, *crinoid stems*.

6299 and others, *bivalve shells*.

6288, *reptilian vertebræ*.

10113, *belemnites*.

1331, 10112, and others, silicified wood more or less opalised.

The Cretaceous strata contain boulders of Devonian quartzite. These boulders are sometimes more or less opalised—see 9127 and others, and, in particular, 5800—in which the opalisation has only invaded the boulder to a moderate depth. From such specimens as these it is very evident that the opal has been produced by *deposition from water*.

3934. Beautiful polished slabs of opalised sandstone, in which sections of bivalve shells are very clearly seen. In case 128, near the entrance, will be found a block of opal matrix showing wood and shells replaced by opal.

Abercrombie District, Ballina, at Rocky Bridge Creek.

In the Abercrombie District and at Ballina precious opal has been found as amygdalæ in basalt, the original vesicular cavities having been filled up by opal deposited by water (2637, 5394 and 10126).

PLATINOID METALS.

The principal metals of the platinum group are *platinum* itself, **Case 48.** *iridium*, and *osmium*, the two latter being frequently found together forming the alloy *osmiridium* or *iridosmine*. Practically they are only found in alluvial deposits.

Platinum fuses at exceedingly high temperature only, and is unattacked by most acids. It is, in consequence, largely used in the form of wire, foil, and crucibles for chemical purposes.*

Another important use of platinum is in the preparation of the platinotype papers used in photography.

Iridium and *osmiridium* are used in the manufacture of incandescent mantles and, in the form of grains, for tipping certain pens. A minute quantity is obtained from gold bullion at the Royal Mint (5930). The grains are steely in colour and generally flaky in nature. While platinum can be dissolved in aqua regia (a mixture of one part of concentrated nitric acid with four of hydrochloric), iridium and osmiridium are quite insoluble. 9367 consists of iridium grains, and is believed to have come from the Macleay River.

Platinum has been found in certain deposits—ironstone and the decomposed rocks beneath them—near Broken Hill. Assays **Platinum.** give very varying results, but 2 oz. per ton have been obtained. There is at present no prospect of successfully working the material. Specimens are exhibited.

Beach Sands.—On both the Australian and American coasts of the Pacific, the beach sands are sometimes found to carry gold and platinum. For convenience, specimens of such sands from New South Wales, although in reality worked for gold, are placed here. It is on the Northern beaches only, and more

* The high price of platinum articles has given rise to the wide-spread fallacy that crude platinum is more valuable than gold, no allowance being made for the treatment that has to be undergone before it is converted into a commercial product. While gold is found in a state of comparative purity, requiring fluxing only to free it from gangue, or alloyed with silver from which it can be readily separated, crude platinum, as will be seen by reference to the analysis given with 5369 (page 23), is alloyed with iron, osmium, iridium, and other substances which have to be separated from it. Moreover, while the value of fine gold remains fixed at eighty-four shillings per ounce troy, that of platinum fluctuates, and can be controlled to some extent by interested parties.

Case 48. particularly near the mouth of the Richmond River, that profitable workings have been carried on, operations being, as a rule, confined to patches of sand that have been naturally concentrated by the sea. In addition to quartz—which can be readily removed—the sands contain zircon in abundance, and sometimes tin-stone, both of which minerals are considerably denser than quartz, and cannot be readily separated from gold by washing. After concentrating the sand as much as possible, the miner saves most of the gold by means of quicksilver, leaving the platinum, tin-stone, zircon, and some of the gold in the concentrates. The samples of sand exhibited are all concentrates, quartz having been removed by washing. It will be noticed that the assay value of these concentrates varies much. The character of the gold and platinum can be judged from 4069, the metals occurring as very minute flattened discs. It will be readily understood how difficult it would be to save this material by mechanical processes such as washing. Quite recently, however, successful concentration has been accomplished, and parcels of clean tin-stone and platinoid metals have respectively been placed on the market. Specimens of these concentrates are exhibited (10204). Inland there have been found strips of loosely coherent sand coated by organic matter, which are evidently of similar origin to those occurring on the present sea-beach, but have been cut off by the erection of ridges of sand-hills. These are known as “leads,” and one of them—McAulay’s—yielded much gold (see 6317, &c.). The gold in these leads is sometimes coated with substances which protects it from the action of the quicksilver. Boiling with caustic soda has generally overcome this difficulty. McAulay’s lead has now been abandoned.

Alluvial.—In the Condobolin district—Fifield, Platina—auriferous alluvial deposits yielding platinum have been worked for some years. The platinum occurs as grains and nuggets. The amount raised in 1899 was 638 oz., valued at £1,070. Several nuggets are exhibited, one of which weighs 27 dwt., and is the largest yet recorded from Australia. Platinum, like gold

and silver, sometimes occurs crystallised in the form of cubes. **Case 48.** Owing to the softness of the metal, these crystals generally lose their shape by being knocked about in the beds of the streams, and are but rarely preserved. One such has been presented to the Museum. It is a somewhat damaged *cube*, the longest side of which is 4 millimetres (about $\frac{1}{4}$ inch) long; the corners are truncated by the *octahedron* (9293). 7658 consists of native gold and native platinum in intimate association. At a higher level than the leads now being worked there is an older drift, also containing gold and platinum in small quantities. It is believed that the newer leads have been formed from the débris of the older ones. 6663, 9292, each containing platinum and gold, illustrate the older drift. 6662 shows the contact between the pebbly drift and the decomposed bed-rock. 6664, decomposed bed-rock, into which grains of platinum have been wedged. 6665, a nodule of magnesite in which is embedded a grain of platinum. This nodule is, in all probability, of secondary origin, and has formed round the grain of platinum. An analysis of the crude platinum shows it to contain 76 per cent. platinum, 1·3 per cent. of iridium, 1·3 per cent. of rhodium, 9·3 per cent. of osmiridium, 10·15 per cent. of iron.

9480: platinum obtained from the alluvial workings (gold) at Warraderry, near Grenfell.

Specimens of Russian platinum will be found in **show-case 77.**

MERCURY.

Mercury—or quicksilver, as it is commonly called—is sometimes found in the form of metal, but more generally has to be extracted from its combination with sulphur as the mineral cinnabar. Specimens of native mercury will be found in **case 77**, more particularly 8410 from California.

Although ores of mercury have been found in New South Wales, Queensland, Victoria, and New Zealand, it has not as yet been profitably mined. The demand for quicksilver in the amalgamation of gold ores would render the discovery of a

Case 48. payable deposit of cinnabar a matter of considerable importance to Australia. A small average percentage of mercury in an ore is sufficient to pay, provided the conditions for working are reasonably favourable.

The cochineal-red colour of cinnabar is very characteristic; as also is its great density. A very simple test is to put a few grains of the mineral into a glass tube closed at one end, and heat it before the blow-pipe. If cinnabar be present, a shining black band will form round the inside of the tube, just above the substance. It is a common error to mistake brownish-red iron ores for cinnabar; but they are not so weighty, and would not give the black ring when heated in the tube.

Cudgong River.—The alluvial drifts occupying an old valley of the Cudgong contain cinnabar along with gold and gem sand. 1045 is a representative sample of the cinnabar obtained by panning the wash-dirt. Coarse pebbles (7310) are sometimes found. Some of the fragments in 9120 are crystalline, but these may have resulted from the breaking-up of the larger pebbles. Specimens of the drift are exhibited. Of these, 1047 shows fragments of cinnabar of considerable size: 9120, pannings consisting of zircon and cinnabar, with free gold. The original source of the cinnabar has not yet been discovered.

Bingera District.—Small quantities of cinnabar have been found at Spring Creek, Bingera, in a serpentinous rock intruding limestones and claystones. 1049 and 6719 represent the rock in which the cinnabar occurs, 2642 and 2643 the mineral itself. 7716 was obtained from a drift, overlain by basalt, at Black Camp Creek. Cinnabar is also shown from Crow Mountain (8976).

Corindi.—9458, in quartz.

Yulgilbar.—At Yulgilbar Run, on the Clarence River, cinnabar has been found in lode deposits. The first discovery was made some years ago at Horseshoe Bend (1043, 5910). The scene of the present workings is several miles from this first find. Several shafts have been sunk, and, in addition to low-grade ore, bunches of rich stuff have been met with. Prospecting is being carried on. The ore occurs in a siliceous veinstuff associated

with calcite, fahl-ore and antimonite. The oxidation of the fahl-ore gives rise to stainings of carbonate of copper in the upper levels (6283). The country rock is a hornblendic granite (6680). This is traversed by a belt of diorite (6637), and it is at the junction of the two rocks that the cinnabar-bearing veins occur. Cinnabar is also found in small quantities impregnating the surrounding rocks.* In thin sections under the microscope the cinnabar is seen scattered through the rocks in the form of microscopical specks. There is the clearest evidence that the cinnabar has been deposited from solution in water. In one microscope section a felspar crystal was seen to have had cinnabar deposited along the lines of cleavage. 9380 is a decomposed rock from near the surface; it contains cinnabar deposited in it in spots by permeating solutions. 6283 is from a bunch of rich ore. 6677 and 7014 respectively show calcite and fahl-ore (antimonial copper ore); and 9378 antimonite, associated with cinnabar. The silica of the vein-stuff is occasionally in the form of crystalline quartz (6283), but is generally in a more or less cherty condition (6678 and others).

Broken Hill.—Small quantities of mercury have been found in the Broken Hill mines, in combination with iodine. These compounds are of a beautiful red colour when found, but rapidly fade on exposure to light; for this reason the specimens are kept covered. 7451 is of special interest, having been formed in the mine-workings of the Proprietary Mine, in consequence of the fire there a few years ago. 1263, from the Consols Mine, is associated with iodide of silver.

Mercury ores from other countries will be found in case 77.

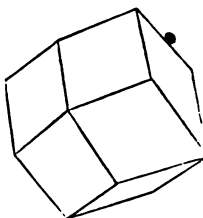
GOLD.

The collection of New South Wales gold ores is contained in cases 50-57. It should be studied from right to left, beginning with number 50. The series comprises crystallised gold, alluvial

* Cinnabar is a very powerful pigment (vermilion of commerce), a minute percentage disseminated through a rock being sufficient to produce a pronounced colouration, thereby giving rise to a deceptive idea of the richness of the ore. Thus the vein in 9379 is not nearly so rich as it looks, consisting largely of stained quartz.

Case 50.**Crystallised gold.**

specimens, and the crushing ores, in the order [mentioned. The best specimens of crystallised gold are generally secured by private persons, and the Mining Museum possesses but few. Native gold crystallises in the cubic system. 2681 consists of the form known as the *rhombic dodecahedron*, in which there are twelve rhombic faces. The crystal on the centre support shows this best.



Crystal of Gold (*rhombic dodecahedron*)

Of the other specimens, 5638, from Grong Grong, is the only one that shows definite outline. The crystals are extremely small, but with a powerful glass triangular faces are readily seen. The form is that of the *octahedron*.

8564 and 2652, Ti Tree, Oakey Creek, Manilla: Here the gold is contained in calcite, and is obtained in a spongy mass when the latter is dissolved in acid.* The spongy mass of gold, enclosed in a glass-capped box for security, really belongs to the specimen immediately preceding it.

A few others are placed here for convenience:

9037, Prince of Wales Mine, Gundagai: shows a speck of gold associated with telluride of bismuth. 2677, Bowling Alley Point, Nundle. 5524, Little Snowball Creek, Braidwood district. 4828, Bingera.

Alluvial gold.

These specimens, consisting almost entirely of miners' "prospects," obtained by panning one or more dishes of wash-dirt, call for no remark. Visitors from Ireland will note that Nature has produced a very good representation of the Harp of Erin.

* Among the exhibits from the Wentworth Mine in case 52 will be found a specimen of pyrites from which the gold has been similarly liberated.

(From Yalwal; on loan to the Museum.) 2654, from Berrima, **Case 50.** is not unlike a fish, but here Nature has been assisted by Man, the tail having been twisted.

The Departmental collection of nuggets and many alluvial specimens are not displayed, the intrinsic value being considerable. Of these the following may be mentioned :—

The “Maitland Bar” Nugget, found by Chinamen at Hargraves in 1887; weight, 344·78 oz., containing 313·093 oz. of fine gold, according to specific gravity test; value, £1,236 14s. 1d.

A nugget of gold from Wood’s Flat, near Cowra; weight, 42 oz. 17 dwt. 5 gr.; value, £168 5s. 5d.

In **case 137**, immediately to the right of the entrance, is a collection of casts of nuggets, some of which are from New South Wales.

A few specimens of wash-dirt succeed the alluvial gold.

**Alluvial
wash-dirt.**

A few explanatory words, for the assistance of visitors unacquainted with mining terms, may be useful here. Rivers draining an area of gold-bearing country carry down rock *débris* into their valleys. In course of time this *débris* is ground down to gravel, sand, or mud, and may be carried for long distances. As the speed of the current slackens, on reaching more and more level country, the heavier portions of its burden will be deposited by the water, forming accumulations on the river-bed. With the rock-material there will be a certain quantity of gold, the particles of which, being malleable, not brittle, are flattened or rounded by the pounding to which they have been subjected. Gold so deposited is known as alluvial gold, and the gravel, sand, or mud in which it is embedded is the “wash-dirt.” When this wash-dirt becomes bound together into a coherent mass by cementing agents, such as oxide of iron, silica, &c., it is known as “cement” by the miners. Gold-bearing wash-dirt is frequently found in the valleys of existing rivers, and the gold may then be won by sluicing or dredging operations. It has sometimes happened, however, that a valley has been filled up by a flow of lava from one of the volcanoes that at one time existed in Australia, in which case the alluvial wash-dirt is buried under a cover of volcanic rock (mostly basalt), through which shafts have to be sunk to get at the alluvial below. Ancient river-valleys, filled up with gold-bearing alluvial deposits, and not now occupied by a running stream, are known as “leads,” while those that are buried under a cover of basalt or other material are “deep leads.”

Case 50. 7521, from the Star Lead, Gulgong, has been obtained at a depth of 195 feet. A specimen of the basalt which covers the Gulgong deep lead is also exhibited.

2140, Gulgong, and others show gold freely; these are exceptionally rich specimens.*

In washing alluvial material to save the gold, various other heavy minerals are sometimes obtained—*e.g.*, *zircon* and *iron-sand*. 3759, Tumbarumba, and others consist of this black-sand, as it is called. The gold and platinum bearing beach-sands in **Case 48.** case 48 (page 21.) really belong here. These sands are found at numerous spots along the New South Wales coast, more particularly in the north. They consist of material that has been brought right down to the sea by rivers. They contain a very large proportion of zircon sand. Now, zircon is a dense mineral, nearly twice as heavy, bulk for bulk, as ordinary quartz sand. It is consequently practically impossible to separate it from the gold by washing. Only the very fine particles of gold have finally reached the sea-coast, and these have been beaten out into flat discs during the lengthened journey from the parent rock. 4069 represents these grains, and it will be readily understood how these flattened grains will tend to float on the surface of the water, thereby increasing the difficulty of saving it. 6749 and others are from the so-called McAulay's Lead, a former beach-deposit that has been cut off from the present coast by the formation of lines of wind-blown sandhills. Such deposits now constitute swampy country, and have been stained brown and become loosely coherent by the action of vegetable matter. A large block of sand-rock, perforated by boring shells, will be found in **case 128.** While much of the gold can be saved by amalgamation with quicksilver, there has until lately been no satisfactory method of extracting of the platinum. All that could be done was to concentrate the sand as much as possible. Tinstone is sometimes present in considerable quantities in these sands.

* Alluvial deposits can sometimes be successfully worked when they do not contain more than a few grains of gold to the load of wash-dirt.

It is intended eventually to arrange here a series of specimens showing gold in association with various minerals.

Case 50.
Minerals
associated
with gold.

9167, gold on *calcite*.

9169, gold on *talc*.

9091, gold on *galena*.

All from the Gilmandyke Mine, Rockley.

From here onwards the exhibits consist of ores that have to be won by regular mining operations from the lodes, or other deposits, in which they occur, and which have to be crushed and submitted to a more or less complex treatment before the gold can be extracted. In the great majority of cases, the ores consist essentially of quartz that has been deposited in fissures or other spaces in the rocks of the earth's crust. In all cases the agent that has brought about the deposition is *water* in some form or other, not *fire*, as is so commonly supposed. Fissures occupied by quartz frequently extend to great, even to unknown, depths; other deposits are more local in character. Various terms are used in describing the nature of lode-quartz. It may be *glassy*, *vitreous*, or *milky* in appearance; *white*, *blue*, or *red* in colour. If stained yellow or brown by the presence of small quantities of iron oxide, it is *ironstained*; when more iron is present, it is *ferruginous*. It may be *cellular*, *honeycombed*, *cavernous*, *saccharoidal*, or *flinty*. **Gold ores.**

In the upper portions of a mine the quartz is generally iron-stained or ferruginous, cellular or cavernous; moreover, the gold is *free*, and therefore easily saved. At lower levels this porous character, and the iron oxide, disappear; the stone becomes compact, and is usually accompanied by iron pyrites (*pyritous quartz*) or other metallic sulphides. This change in the upper levels is due to the action of water and air. In case 113, a set of specimens has been arranged to explain these terms.

Gold-bearing quartz veins are almost entirely confined to the oldest rocks of the earth's crust. Cases are known in

which the reef traverses younger strata—the Copeland Gold-field, for instance, is in Carboniferous rocks; but, generally speaking, it is in strata of the Silurian, or older periods, that they occur. Gold ores are frequently associated with dykes of igneous rock (often diorite), but the connection between the occurrences is not understood.

Gold may be described as occurring in two ways—

- (a) *As free gold*, which may or may not be visible to the eye. Such gold would generally be extracted by passing the finely crushed ore (*pulp*) over plates of copper that have been coated with quicksilver. The quicksilver combines with the gold, forming *amalgam*, and is subsequently driven off again by heating in a retort.
- (b) In combination with iron-pyrites and other minerals, in which case the presence of gold can only be detected by assaying the stone. Special machinery is then necessary to concentrate the gold-bearing minerals from the crushed ore, and special processes, such as chlorination, smelting, or cyanidation, have to be resorted to to extract the gold.

It must be remembered that in general the gold-bearing character of an ore cannot be detected by the eye. The proportion of gold to make an ore payable may be very small, under favourable conditions a few pennyweights of gold to a ton of ore being sufficient. All gold as found in nature contains more or less silver, so that the value of the *bullion* (*i.e.*, the gold and silver together) per ounce varies in different cases.*

The general collection of New South Wales gold ores is contained in eight cases, viz., 50–57. These should be studied from right to left. The ores are arranged in districts, Northern, Western, and Southern respectively; each being subdivided into

* In Australia it is usual to express the value of an ore by the weight (troy) of gold contained in a ton (2240 lb.) of stone. In some other parts of the world the value is expressed in coin of the realm. An American mining engineer would speak of an ore as being worth so many dollars to the ton.

the more important mining divisions. Specimens from any neighbourhood can be quickly found by referring first to the geographical district and then to the mining division in which it is situated.

Copeland, Stewart's Brook, Walcha, and neighbouring Divisions. **Case 50.**

5835, Moor Creek, Tamworth: interesting in containing free gold associated with telluride of bismuth—the leaden-looking mineral. Northern District.

9543, near Moonbi: represents a most unusual mode of occurrence for gold. The ore is a deeply copper-stained garnet rock, assaying $4\frac{1}{2}$ dw. gold to the ton.

Upright **cases 125** and **128**, at the lower end of the room, contain block specimens of gold quartz from the Hanging Rock, Nundle.

Hillgrove, Dalmorton, Bingara, Coramba, Woodburn, and neighbouring localities.—**6973**: granite, the country rock of the Uralla Gold-field. **Case 51.**

From the Hillgrove Gold-field will be found many specimens of great interest. The country rock here is an ancient slate (and also to some extent the adjacent granite), which has been shattered along certain directions by movements in the Earth's Crust. The resulting fragments have been cemented together by quartz which has been accompanied by antimonite and gold (sometimes free). Notice particularly **6615**, **6612**, **2484**, **2567**, and a very fine block specimen in **case 136**, near the door. Sometimes the gold is visible (**6615** and other specimens here, also **2131** in **case 125** at lower end of room). **2525** shows a slickensided surface, proving that movements have taken place between neighbouring masses of rock.

In **case 125** will be found a mass of crystallised pyrites, assaying 4 oz. of gold to the ton, from Glen Elgin.

61 and other specimens from Deep Creek, Nambucca, bring before us the combination of gold with arsenical pyrites (*mispickel*). These ores are more difficult to treat.*

* Pure arsenical pyrites now has a commercial value of its own on account of its arsenic contents,—see page 79.

Case 51. **2624, Mann River:** an instance of gold occurring in calcite.

5547, Manilla: auriferous pyrites with a peculiar structure.

6579 and others, Bingara: gold in serpentine associated with such minerals as talc (**2152**) and chlorite (**1135**). In case **136**, near the door, is a block specimen of the serpentine with fine gold coating the smooth surface.

6969, Golden Crown Reef, Lunatic: Native arsenic containing gold. A specimen formerly in the collections, but unfortunately stolen, showed free gold seated on the arsenic.

7064, Millara Scrub, near Solferino, is very instructive. The pieces exhibited consist of brown oxide of iron (*limonite*). That they were at one time pyrites is shown by the crystalline form, and by the kernel of pyrites still remaining within one or two of the crystals. Gold is freely visible. Numerous other instances of this transformation will be referred to in this guide.

The alteration of the original pyrites is the result of the action of surface waters, and of the atmosphere. Under the influence of oxygen (from the air) and moisture, the sulphur is converted into sulphuric acid, and is removed in solution, while the iron is oxidized and hydrated, and remains behind as limonite. The process is technically described as a *pseudomorphous replacement of pyrites by limonite*. The resulting limonite cubes are known as *pseudomorphs after limonite* by the geologist. They are the "devil's dice" of the miners. For other instances of pseudomorphous, replacement, see **Students' case 33**.

Timbarra.—The auriferous granite from Timbarra, represented at the left hand end of this case, is particularly worthy of attention. That the rock is truly granite is evident enough, and that it contains gold receives ocular demonstration from **9124** and **2151**. The gold occurs along a belt, several miles long, of a granite plateau. The alluvial in the valleys draining this plateau, which has resulted from the degradation of the granite, has yielded much gold. The granite itself has been softened by atmospheric weathering, for a depth of several feet. This soft material, which is generally red or yellow in colour owing to the oxidation of iron, is excavated and ground-sluced; the undecomposed portions being left standing in large masses. The average

yield is from 2 to 4 dwt. of gold to the ton, but assays of 9 dwt. or more have been obtained, the loss being due to the extreme fineness of the gold. Several very narrow veins of auriferous quartz, and a dyke of eurite—which is itself gold-bearing in places—traverse the granite. The secondary minerals found in the granite are *quartz, iron and arsenical pyrites, molybdenite, and native bismuth*. The points just referred to are all illustrated by specimens.

Drake—

8783, Sawpit Gully Mine, Drake: Breccia from the 100-ft. level. **Case 53.** Gypsum associated with free gold. This ore also contains silver. (See case 53). In the ore from Long Gully (Lady Jersey Mine), Drake, zinc blende is associated with free gold. 2155 shows gold conspicuously seated on blende. Another gold-bearing breccia is that from Wann's Lode, Drake; it consists of igneous material—felsite (6593).

2801, in upright case 125, at lower end of room: Quartz showing gold; Lady Jersey Mine.

Oberon, Newbridge, Bathurst, Sofala, Tuena—

Western
district.

8540, Hazelgrove, near Tarana: Noteworthy in containing much telluride of bismuth, associated with free gold. So far as is known, the telluride is not auriferous itself.

The exhibit from Gilmandyke (9167-8; also 9167, 9169, 9091 in case 50) is rich in attractive mineral specimens. Thus we have gold on calcite, galena, talc, and serpentine from this one mine. 9168, gold on fibrous serpentine, may be compared with similar specimens from Gundagai (case 55, p. 40).

7670, Quartz from Clear Creek; shows gold seated on galena.

6676, Wattle Flat: gold seated on arsenical pyrites.

2158, Razorback, Ilford: gold-bearing sulphide of antimony ore (*cf.* Hillgrove, case 51).

Carcoar, Mandurama, Blayney, Lucknow.—The ore from the **Case 52.** different mines at Mandurama is of a very peculiar and interesting

Case 52. character. The strata in which they occur constitute bedded deposits of early Palaeozoic age, and comprise volcanic tufts and radiolarian-bearing cherts, in addition to the ore-body itself. The ore-body itself is a bed of highly metamorphosed rock, charged with pyrites, largely arsenical: there is no lode at all. 9045, in case 109, shows the junction between the chert and the ore-body; 9074, the original bedding in the chert. 9044 and 9221 are characteristic specimens of the ore-body; their dark green colour being due to shreds of hornblende scattered through the mass, while the presence of calcite is indicated by the glassy lustre.

At Brown's Creek, Blayney is another remarkable occurrence of gold. Near the surface, the ore consists of copper- and iron-stained chalcedonic or opaline silica. In this gold is sometimes visible (2439). At somewhat deeper levels a wollastonite garnet rock (6482, assaying 5 dwt. of gold to the ton) and massive magnetic pyrites (6504, assaying 3 dwt. gold per ton) occur. The deposit does not appear to be a lode formation. The white mineral is *wollastonite*, the brown *garnet*.

To the courtesy of Mr. Warneford Lock, late manager of the Wentworth Proprietary Mine, the Museum is indebted for the carefully-selected specimens exhibited here. Many of these are accompanied by statements of the composition of the ore and the value of the gold. The rock most directly associated with the gold is serpentine. This serpentine has resulted from the alteration of an intrusive igneous rock containing much augite. The minerals of most frequent occurrence in the ore are *calcite*, *iron and arsenical pyrites*, *magnetic pyrites*, *native antimony*, and *antimonite*. 9236, a pretty specimen, in which free gold has been deposited along the cleavage planes of the calcite. (See also 9235.) Arsenical pyrites frequently shows gold freely; at other times the assay value may be very high without gold being visible. 6710, arsenical pyrites cut and polished to show the manner in which the free gold ramifies through the pyrites.

9238, pyrites after partial pickling in acid. Much of the **Case 52**. pyrites has been dissolved, leaving the contained gold as a residual spongy mass.

9242, rich pyrites in which gold is not visible. The analysis shows that much calcite is present. The assay value of the ore is 154 oz., the bullion being very pure (.987 per cent. of fine gold) and worth 83s. 10½d. an ounce.

9232, 9226, magnetic pyrites. This is generally barren.

A very fine specimen of native antimony in calcite from this mine will be found in **case 68**.

9233, crystallised native antimony with calcite, showing gold. Assay value up to 27 oz. per ton, the bullion being very pure and worth 83s. per ounce.

9229, antimonite with calcite, assaying 6.61 oz. of gold to the ton.

Orange, Ophir.—**8610**, Weir's Consolidated Mine, Caloola. This is another instance of gold being contained by an igneous rock. The rock is a quartz-porphry that has been crushed under the influence of pressure within the earth's crust; it is sometimes known as *porphyroid*. The ore from Bushy Hill, Cooma, is of this character (**case 57**, p. 41).

7409 and **7410**, *Caloola Creek*: The country rock here is mica-schist,* which itself sometimes shows visible gold (**7409**).

Hill End, Cowra, Wellington, Mitchell's Creek, Stuart Town.—An examination of the specimens from these divisions indicates slate to be the country-rock, while the gold is contained essentially in the quartz lodes that traverse it.

4557, Lower Pyramul: free gold and gypsum in arsenical pyrites.†

2472, Eaglehawk, Windeyer: shows gold seated on blende.‡

2187, Salvation Hill, Gulgong: an instance of hard felsite carrying gold.

* It is conceivable that this mica-schist may represent an intensely altered form of **8610**.

† For other occurrences of gypsum with gold, see pages 27, 32.

‡ For other occurrences of gold on blende, see pages 27, 30, 35.

In case 128, near the door, will be seen quartz from the Madman's Reef, Stuart Town: a complete section across the reef.

Case 54. *Cargo, Forbes, Peak Hill, Parkes.*—9052, Homeward Bound Mine, Grenfell: gold seated on blende. 9051, from the same mine: showing gold seated on arsenical pyrites.

7708, country rock (slate) from the Tomingley Mine. This is one of the very few instances in which fossils have been found in the slate which so commonly constitutes the country-rock of our gold-fields. Numerous fairly well-preserved remains of lowly forms of marine organism known as *graptolites* have been found in the mine, and by their means it has been proved that the slate is of Lower Silurian (Ordovician) age. The impressions of the graptolites can be easily seen on 7708. Better specimens will be found in Fossil case 1.

6492, 2160, and other specimens of gossan from Peak Hill should be compared with the surface ore from Mount Morgan (Queensland) in case 80, the iridescent appearance being very similar.

2145, Condobolin: red clay-slate, on which fine gold is readily visible. Numerous similar instances of gold occurring in this way will be found in the collection.

2503, Koh-i-noor Mine, Parkes: white quartz. Yet another instance of gold occurring on blende, several such having been already mentioned in this Guide.

6490, Round Parkes there is a good deal of the volcanic rock known as andesite, which appears, indeed, to be the principal country-rock of this mining district. It is sometimes incorrectly called diorite. 6490 is a block of this rock traversed by quartz veins carrying pyrites, thus illustrating in miniature the occurrence of the lodes.

Bobadah, Nymagee, Cobar, Mount Drysdale.—The Cobar Gold-field is represented by numerous specimens, from a general inspection of which it will be seen that the country-rock is slate,

and that, while the gold is frequently contained in the slate **Case 54.** itself, it is often associated with copper ores.

6980, 8921, and others are blue slate showing gold in a very fine state of division, while **1388** and other iron-stained or bleached slates show the same rock under the influence of weathering. At times, as in **8926** from the Conqueror Mine (100-ft. level) and **6568-9** from the Occidental Mine, the gold occurs with quartz. **8929, 8930**, Great Western Mine, Cobar, show fine scales of native copper on the slate. **6570** and others from the Chesney Mine, Cobar, show carbonates of copper. In case **60** will be found a specimen (**8938**) from the Great Peak Mine (120 ft.) showing chloride of silver.

The occurrence of gold at Billagoe is very similar. **814** is a bleached slate showing gold; **5438**, slate showing gold and chloride of silver.*

At Mount Drysdale the ore consists of slate, conglomerate, &c., in which gold is sometimes freely visible. **1951**, in case **136**, near the door, is a block of breccia from Drysdale in which gold is very freely visible. **5420**, clay-slate showing very fine gold. **7669**, very rich stone showing veins of gold traversing slate. **8974** shows antimonial silver ore on which is seated a very pale variety of free gold. There is some superficial resemblance between the Drysdale stone and that from Pambula (case **56**). The nature and origin of the two is, however, totally dissimilar, the Pambula ore being wholly of igneous formation, while that from Drysdale is wholly sedimentary, not being associated with any igneous rocks whatever as far as known.

8546, Florida Run, blue slate and its weathered representative, showing gold and silver chloride.

Mount Hope, Gilgunnia.—**6769** Mount Hope, and **9321** Mount Allen, show free gold on red slate. In case **136**, near the door, is a block of ore from the May Day Claim, Gilgunnia, 168 tons of which yielded 366 oz. of gold.

* Chloride and bromide of silver blacken very rapidly on exposure to light and the original colour cannot be restored. For this reason **8938** is kept covered. In **5438** the silver mineral forms a greenish-black coating on the stone.

Case 54. *Tibooburra, Milparinka, Broken Hill, Silverton.*

Case 55. *Wyalong.*—This gold-field is, perhaps, better represented in the collection than any of the others. The series commences with the country-rock and a few special exhibits; then succeed the gossan and ore from the upper levels, followed by the sulphides.

Southern
District.

The country-rock would be popularly known as granite. Strictly speaking it is more akin to quartz-diorite, and in places becomes even more basic in character. For ordinary purposes hornblende-granite is a sufficiently accurate name. 4007 shows it in its disintegrated weathered condition from near the surface, while 6775, from a depth of 13½ feet in the Welcome Stranger Mine, is the solid rock.* 9136, ferruginous quartz showing gold, is of historic interest, being one of the earliest specimens found by the original prospectors. 9133, a nodule of carbonate of magnesia found in the sub-soil. These nodules are undoubtedly of secondary origin, being due to the action of water. The decomposition of hornblende in the country-rock would supply the magnesia. 5770, 9137, a brown variety of common opal showing gold. Such specimens were not uncommon in the upper levels, and represent an unusual occurrence of gold. It may be compared with the similar stone from Brown's Creek, Blayney (page 34, case 52). 9139 from the Monte Christo is manganese-stained. Passing over the different varieties of auriferous quartz, we come to 8118 from Klink's Mine, 150-ft. level, quartz, distinctly chalcedonic, assaying 18 oz. of gold per ton, none being visible to the eye. 9135 from Stanley's Blow should be noticed: a kernel of pyrites is enveloped by ferruginous red quartz showing a concentric zone of free gold. 8224, from the Red Flag, is cellular quartz. The cavities are due to the decomposition and removal of pyrites, from which the free gold contained by some of them may reasonably supposed to have been derived. 8219 shows gypsum associated with free gold. 9132, Native copper from the Klondyke Mine (300-ft. level). This mineral occasionally occurs, and is not regarded as a

* The depth to which the decomposed rock extends depends upon various circumstances. On the Wyalong field it is sometimes very considerable.

favourable indication. At the Klondyke it occupies rectangularly-disposed cracks in quartz, and thereby assumes a leafy form. A piece of native copper with a rectangular bend, and quartz showing the same mineral, are exhibited. **Case 55.**

The remaining ores are sulphides from the deep levels. Such ore is reached sooner or later in all the mines, and is sometimes of great richness, **9063** assaying 20 oz. of gold per ton. The chief constituent of the sulphide ore is pyrite; galena is not uncommonly present (**9144**); blende and copper pyrites occur occasionally. **9141**, from a depth of 300 ft. in the Lucknow Mine, shows pyrites that has been grooved and polished—*slickensided**—by movements of the walls of the lode; free gold has been deposited in films upon the polished surface at a later date. A block of rich ore from the Lucknow Mine is shown in **case 125**.

Temora†, *Gundagai*, *Wagga*, &c.—In this group will be noticed several instances of free gold coating clay-slate, viz., **6549**, **2134** from Cowabbie; **2135** from Grong Grong, and **2156** from Barmedman.

Crystallised gold from Grong Grong is shown in **gold-case 50**. (see page 26).

6984, Bongongolong; magnetic pyrites with free gold seated upon it; an unusual mode of occurrence. **5810**. Ph. Burra, Co., Clarendon; magnetic pyrites with galena, assaying 22 dwt. of gold to the ton, though not showing gold; another instance of this exceptional association.

2498, Bongongolong; one of those rare instances in which porphyry is the country-rock. The specimen, which has been cut to show the structure better, consists of quartz-felspar-porphyry traversed by veins of white quartz in which gold is freely visible. It is worthy of particular attention. The occurrence of gold at Cargo is similar.

* Specimens such as this prove that the gold contents of a lode are subject to rearrangement. In this case, in all probability, the gold was originally contained in the pyrites, but was subsequently dissolved out, and then re-deposited.

† The Department possesses a rich specimen from the Mother Shipton Reef, Temora, containing 258 oz. of gold, and valued at more than £1,000.

Case 55. Of the Gundagai exhibits the series from the Prince of Wales Mine is of special interest from the association of tellurides of bismuth with the free gold, and particularly because the existence of telluride of gold has been detected (9035), though not in tangible grains. The stone consists of white quartz of a more or less milky character, sometimes associated with copper ores. Telluride of bismuth (9035) appears in platy grains of a steely or tin-white colour. Analysis has shown that lead enters into the composition of the mineral, which would therefore not be true tetradyte, and may be an undescribed species. Glass slips showing metallic tellurium, separated from the ore by chemical means, are placed with 9035. In case 109 is a block of slate (9001) traversed by a vein of gold-bearing quartz from this mine.

5773, 6335, Gundagai, are further instances of gold on slate. In every case yet referred to in this guide (see pages 30, 31, 33), the gold has been found coating the cleavage faces of the slate; in this instance, however, it is found abundantly on an uneven joint-face.

Yet another interesting exhibit from Gundagai is fibrous serpentine (*picrolite*) coated with filmy gold—2225, 6331. Such specimens are very difficult to preserve, as the gold so readily becomes detached.

2159, Cubes of pyrites, with an outer layer of limonite (see p. 26). The limonite is coated with free gold.

Several specimens of mica-slate showing gold, from the neighbourhood of Albury, will be noticed. The rock was most probably originally a clay-slate, but has been metamorphosed (5775 and others).

Case 57. *Adelong, Murrumburrah.*—As at Timbarra, the country rock at Adelong is granite, which is sometimes itself auriferous.—(6538)—Chlorite schist (6510) also occurs. 9173 from the Challenger Mine illustrates in miniature the occurrence of the ore-bodies. The rock is a fine-grained granite and contains lenticles of quartz connected by strings of the same mineral

Similarly, the ore-bodies occur in lens-shaped masses, connected by the ore-channel. The ore in general is a glassy quartz with iron- and copper-pyrites. Blende sometimes occurs, as in 2231, from the Currajong Mine. **Case 57**

1275, from Cullingar, a gold ore assaying 4 oz. to the ton. It contains pyromorphite—the earthy yellow substance—a mineral which consists of lead combined with phosphoric acid and chlorine and is not often associated with gold.

7325, from near Harden: yet another instance of gold in granite country. The specimen, a similar piece to which assayed $2\frac{1}{2}$ oz. of gold per ton, shows a vein of quartz with galena and arsenical pyrites; a portion of the granite country rock is still attached.

Cooma, Kiandra, Nimitybelle.—8733, bleached felspathic rock from the Big Badja River. The gold here must be contained in the rock itself, as it will be noticed no quartz or ferruginous veins are present.

8579, Middle Flat, Cooma, shows gold seated on blende. Several instances of this mode of occurrence have been already mentioned (page 29).

Particular attention might be given to the ores from Bushy Hill, Cooma. 9067, Willmott's Claim (135-ft. level); a pretty little specimen, consisting essentially of galena and pyrites, showing free gold richly. The country-rock is very remarkable, the only similar instance being 8610 from Caloola (see page 35). It is a quartz-felspar-porphyry—*i.e.*, an intrusive igneous rock, not a fissure lode. Under the influence of stupendous pressure within the Earth's Crust—due to the movements which give rise to mountain chains—the porphyry has been rolled out to such an extent as to give it a slaty structure. The quartz and felspar crystals have been flattened out into lens-shaped masses. Another effect of this rolling out and stretching has been to produce spaces in which, at a later date, water has deposited the metallic ores. 9272 shows the rock in its normal condition, 8535 after weathering.

Case 57. 1156, 1148, Cowra Creek, and 2041 Flyer's Creek, slate show gold on the cleavage faces.

Yass.—7350, Nanima Gold-field: quartz with sulphide of bismuth, assaying 1 oz. 7 dwt. gold per ton and 6·3 per cent. of bismuth. The stone is concentrated and sold as a bismuth ore. *Tetradymite* and *montanite* also occur at this mine (see page 91).

8728, Murrumbateman: a gold ore of very unusual character. It consists of an aggregation of garnet crystals and assays $3\frac{1}{2}$ oz. of gold per ton.

5318, Dairy Creek, Gundaroo: an attractive specimen showing free gold abundantly on arsenical pyrites.

From the Bywong and Gundaroo Fields are numerous samples of auriferous quartz, which is frequently characterised by its blue colour and glassy lustre—*e.g.*, 6755. 6720, Johnston's Claim, Bywong, differs entirely from the rest of the specimens. It is probably a portion of the country-rock impregnated with metallic sulphides; the assay value is $1\frac{1}{2}$ oz. of gold per ton. The country-rock at Bywong is sedimentary origin (5308-9).

Braidwood.—The ores from Braidwood and Major's Creek are generally rich in pyrites; they sometimes contain fahl-ore and a good deal of blende. 9115, Hanlon's Reef, Major's Creek: a portion of a vein in which quartz with iron- and copper-pyrites, blende with galena, and finally fahl-ore—the steely gray mineral—are successively met with in passing inwards from the walls. As the filling-up of a vein by mineral-bearing solutions necessarily begins with the walls, fahl-ore must have been the latest mineral deposited. This ore assays $6\frac{1}{2}$ oz. gold and 55 oz. silver per ton.

The pyrites from Major's Creek is sometimes crystallised in cubes (2574).

5617, Hornblende granite: the country-rock of the Major's Creek Gold-field.

Case 56. *Tumut, Yalwal, Moruya, Wagonga.*—At Batlow gold occurs in a curious complex of metamorphic rocks difficult to understand—*e.g.*, 5462. Gold is sometimes visible in them (5461).

The country-rock at Yalwal is a highly-altered slate (5642), **Case 56.** and the gold appears to be contained principally by narrow ferruginous veins traversing it. In **case 136**, near the door, will be found a very fine block admirably showing the nature of the Yalwal ore. The slate is traversed by a network of quartz which is fringed by narrow gold-bearing veins. One such vein goes right across the specimen. **9462** in this case is similar.

At Grassy Gully, only 8 miles from Yalwal, the ore is of an entirely different and very extraordinary character. Microscopic examination has shown that it is an ancient lava flow, the rock *rhyolite*, highly altered during the course of geological ages. The gold occurs right through the stone in a very fine state of division (**9175**, and others). This Grassy Gully ore is closely analogous to that from Pambula shown in the same case (see page 44).

8985, Moruya Gold and Silver Mine: solid arsenical pyrites, assaying 15 dw. gold and 10 oz. of silver per ton.

The Mount Dromedary Mine is of considerable interest. Mount Dromedary is a mass of granite rising up through the surrounding slate. The granite is traversed by very narrow veins of pyrites, which are sometimes rich in gold. The pyrites is associated with small quantities of chalybite, sulphide of bismuth, &c. **8582** shows a little acicular black bismuth ore. **8853** has been cut and polished to show the brecciation often present: it will be noted that the pyrites occurs in angular fragments. The pyrites is in a very unstable form, decomposing so rapidly that specimens are most difficult to preserve. At Wagonga Heads there is a dyke of gold-bearing felsite (**8385**).

Wolumla, Yambulla.—**6410**, Auriferous pyromorphite,* from near Wyndham.

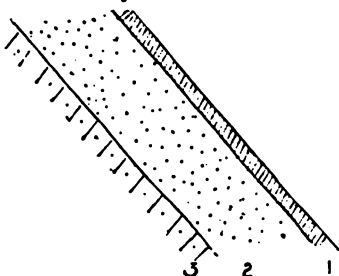
At Wolumla the country rock is granite, and the ore itself is in part impregnated granite. **7348**, Wolumla, rotten granitic rock showing gold.

* Page 41 for other instances of this.

Case 56. The newly discovered gold-field of Yambulla is in granite country, the granite itself sometimes showing gold (9449), but the ore is principally quartz, carrying sulphides at a depth.

Pambula.—The well-known Pambula Gold-field was for a long time a puzzle. The gold occurs as an impregnation in the country-rock, which was formerly regarded as a sedimentary rock, but is now definitely proved to be volcanic rock (rhyolite). The evidence for this is obtained principally by means of the microscope, but 7782 affords ocular demonstration, the banding in the rock representing the lines of flow of the molten rock. The Pambula rock is much altered, but 7782 may be compared with rhyolites of less ancient date.* It would be popularly known as felsite, and may be compared with the Grassy Gully ore, see (page 43).

7773-4-5 illustrate the occurrence of the rich shoot at the 200-foot level in the Victory mine.



The band marked 1 in the diagram is a thin quartz vein on the hanging wall. It is a constant indicator of the ore body, and is known as the "Pilot."

7777 is a portion of the indicator from Faulkner's Mine. 7779, 7781 from the rich shoot in Faulkner's, the former assaying from 50 oz. to 150 oz. of gold per ton. 9481, Pambula Mines, showing gold freely.

In end compartment of case 65 will be seen a block of ore from the Mount Gahan Mine showing the brecciation sometimes noticeable in the ore.

* From Hungary, in case 119; from Raymond Terrace, in cases 143 and 147.

SILVER.

The New South Wales silver ores are contained in cases 58 to 61. They are arranged in three main groups, representing the Northern, Western, and Southern Divisions of the State, the ores from each district being kept together as far as possible. Consisting largely as they do of argentiferous galena, little comment will be necessary. In many instances the assay value of an ore is stated on the label. Generally speaking, the silver is contained in other minerals, notably by lead ores. In one or two cases, however, definite silver minerals constitute an appreciable proportion of the ore; thus, at the Consols Mine, *dyascrasite* and *stromeyerite*, and at the Ruby Silver-mine, *pyrargyrite*, occur in considerable abundance, while in the upper levels of the Broken Hill mines large quantities of *embolite* occurred.

To avoid repetition, a brief description of the more important silver minerals, as found in New South Wales, and contained in the Museum collections, is now given:—

NATIVE SILVER, metallic silver (in filamentous or spongy masses; frequently much tarnished): Broken Hill, Burragorang, Lewis Ponds, Rockvale, Sunny Corner, Umberumberka, White Rock.

HORN SILVER, silver chloride (silver, 75 per cent.): A soft, waxy mineral, greyish-black in colour owing to exposure to light. Of the substances known as chloride of silver, some prove on investigation to be chloro-bromide. The general term "chloride" is a convenient one pending examination. True horn silver occurs in considerable quantities in some of the Silverton mines. It has also been detected at Burragorang, Captain's Flat, Lewis Ponds, Rockvale, and Umberumberka.

IODARGYRITE, or **IODYRITE**, iodide of silver (silver, 46 per cent.) —Very soft and waxy; lemon-yellow in colour; usually forming incrustations, but sometimes found in six-sided prisms with flat terminations. Broken Hill only.

EMBOLITE, chloro-bromide of silver (silver, up to 72 per cent.): Very soft and waxy; beautiful green in colour, but rapidly

blackening on exposure to light; occurs massive or encrusting, but at Broken Hill frequently found in crystalline spongy masses, or in definite crystals belonging to the cubic system. Broken Hill, Billagoe, Cobar, Silverton.

DISCRASITE, silver antimonide (silver, 78 per cent. or more): Rather soft; silver-white in colour; uneven fracture; often taken for native silver. Consols Mine, Broken Hill.

ARGENTITE, silver sulphide (silver, 87 per cent.): A soft, black mineral, perfectly sectile. Wollomombi, Drake.

PYRRARGYRITE, sulphide and antimonide of silver (silver, 60 per cent.)—Colour black, sometimes reddish. The lustre of the mineral and the cochineal-red colour of the powder are of great assistance in recognising it. Burragorang, Consols Mine (Broken Hill), Drysdale, Rockvale and other districts in the vicinity. It occurs in quantity at Rockvale only; crystals are very rare.

PROUSTITE, sulphide and arsenide of silver (silver, 65 per cent.): Very similar to pyrrargyrite. Rockvale, Rivertree.

STEPHANITE, sulphide and antimonide of silver (silver, 68 per cent.): Black in both colour and streak. Rockvale, Consols Mine (Broken Hill).

Case 58.
Northern
District.

Wollomombi.—8342-8348, ores consisting essentially of quartz, with small quantities of disseminated sulphides; the silver contents are sometimes very considerable—386 oz. per ton in 8347. Silver sulphide (*argentite*) is sometimes present (8342), but is difficult to recognise. From Kessler's Mine some richly argentiferous siliceous and arsenical pyrites is exhibited. 8608, from a narrow vein in granite, contains a little native silver.

Tilbuster.—8604, galena ore occurring in slate country at the Mary Ann Silver-mine. From the hanging-wall of this mine a pretty formation of ruby silver has been obtained, the mineral, which is of a deep puce colour, occurring in fern-like encrustations (8605).

Tait's Gully, Armidale.—Rich ruby silver ore has been found **Case 58**, here. 8601, a siliceous ore, assays 3 oz. gold and 666 oz. silver per ton. It is an unattractive-looking ore, but with a glass the characteristic lustre of ruby silver can be detected.

Rockvale, Armidale.—Silver ore, more particularly the ruby variety, and argentiferous arsenical pyrites, have been frequently found here. The Ruby Silver-mine is on payable ore. The deposit differs from all other silver properties in New South Wales, except Broken Hill, in the variety of silver minerals that are found, viz., *native silver*, *pyrargyrite*, *proustite*, *horn silver*, and *stephanite*. 7740 shows native silver in its characteristic thread-like form; while 6587 contains it as spongy brown masses, the value of which might be overlooked at first. 6339, shows a black encrustation of silver chloride. The ruby silver ore is commonly the antimonial variety, *pyrargyrite*, two specimens of which, 6225 and 6227, are shown here. A block of arsenical pyrites, traversed by a vein of *pyrargyrite*, is exhibited in case 128; while 7691, in case 125, shows the same minerals well crystallised. The arsenical ruby silver ore, *proustite*, appears to occur in small quantities only. 6369, a black antimonial silver ore, probably *stephanite*.

6227, an average specimen of the silver-bearing arsenical pyrites which constitutes the bulk of the ore.

7693, altered granite, representing the country rock.

Emmaville.—8795, Webb's Mine, illustrates the mode of occurrence of silver ores in this district. The rock is a metamorphosed slate; it is traversed by veins of quartz, calcite, blende, and arsenical pyrites.

Fahl-ore is not uncommon as an ore of silver in the Emmaville district. 8236, Webb's Consols Mine, shows it in association with galena. 2431 and others from the Little Plant Mine are similar.

Bolivia.—In addition to galena, blende, pyrites, and fahl-ore, a sulphide of lead and antimony, the mineral *jamesonite*, occurs

Case 58. in some of the silver ores from this district. 8334, Pye's Creek, a galena ore assaying 43 oz. of silver per ton, shows jamesonite as a grey fibrous mineral, gradually eating into the galena; the former mineral apparently resulting from the alteration of the latter, sulphide of antimony being super-added to and combining with the sulphide of galena previously there; the ore contains more than seven per cent. of antimony.

Bora Creek (Howell), Inrerell.—Galena and mispickel with quartz and chlorite. The occurrence of massive *stannite* (tin pyrites) in the Bora Creek ore is a specially interesting feature: good specimens of the stannite will be found in case 66.

Drake.—The silver ores from this district are noteworthy, both from the difficulty of treatment and from their mode of occurrence. They consist in general of sulphides, among which the undesirable zinc blende is sometimes conspicuous. Native silver occurs occasionally—5208, 6371, 9102, from White Rock—and arsenical ruby silver, proustite, has been found in small quantities at Rivertree (2394). Silver sulphide, argentite, can be seen in quartz from the recently discovered Kelly's Lode (9101). 9100 shows the globule of silver resulting when ores such as 9101 are roasted. The well-known White Rock Mine is represented here by a number of specimens; while in case 136 is a block showing quartz alternating with bands of pyrites, galena, and blende. The country-rock, 6972, appears to be porphyry; while the ore-body itself is a breccia, consisting of irregular masses of a volcanic rock (rhyolite) cemented together by mineral matter. This is well shown by 8313. The ore from Wann's Lode is very similar: it contains selenite (8783).

At the end of this case will be found specimens of silver ores from Boorook. The oxidised ore was very rich, but the deposits have not been worked below water-level.

**Barrier
Range.**

Broken Hill.—The collection of specimens from the Broken Hill Silver-field is, perhaps, the best outside Broken Hill. In addition to this case, which is entirely devoted to Broken Hill silver ores, a special collection, presented by Mr. Watkins, is

PLATE II.



CRYSTALLISED CERUSSITE, BROKEN HILL.

contained in a cabinet on the left of the entrance. Case 127, at the lower end of the room, contains picked specimens. *This case is kept covered to protect the specimens from the action of light. Visitors are requested to carefully replace the cover. The exhibit consists of a series of the characteristic ores, followed by definite silver minerals, classified according to composition. Case

ORES.—These are under five headings, viz., *gossan, massive carbonate ore, kaolin ore, garnet sandstone, sulphides.*

The gossan is often rich in manganese, and frequently forms stalactitic masses, as shown by 1338 and 2095, and on a larger scale in case 127. 1091 shows embolite.

The kaolin ore contains garnets and quartz; it is undoubtedly the material resulting from the alteration of felspathic rocks such as gneiss. Iodide and chloro-bromide of silver are frequently found in this class of ore; as will be seen further on, some of the best specimens of iodyrite occur in the kaolin. The so-called garnet-sandstone, or garnet-quartzite ore is a granular rock consisting of garnet, rhodonite, and quartz more or less impregnated with metallic sulphides; the prevailing red colour is due to the garnet and rhodonite. The sulphide ore itself is essentially an intimate mixture of galena and zinc-blende. The blende is a troublesome mineral to deal with in dressing and smelting, and the problem of separating it from the galena, and converting it into a useful article of commerce, such as zinc-white, is a very difficult one.†

SILVER MINERALS.—6986, Native Silver on copper ore.

5537, a pretty little specimen of crystallised *cerussite*, with native silver scattered over the crystals.

* The copper, zinc, lead, and other minerals associated with the silver ores will be found each under their respective headings.

† The remarkable saddle reefs, which constitute the ore-bodies at Broken Hill, with the exception of the Consols Lode, are not referred to here, as they cannot be illustrated by hand specimens. A large collection of the metamorphic rocks will be found in case 73.

Case 59. When in kaolin, native silver always seems to assume a leafy form, of which there are several examples. Not uncommonly it occurs in ironstone; of this, **5539** is a fine instance.

Yet another interesting occurrence is that on native copper. **1268**, consists of fragments of white quartzite entangled in native copper, on which the silver is scattered in crystalline groups. **1359**, while consisting principally of massive carbonate of lead, shows the same two native metals associated.*

5540, ferruginous quartzite, shows chloro-bromide with native silver seated on it or growing from it. It will be noted that the silver minerals seem to occur only on the ferruginous patches.

Dyscrasite, antimonide of silver. This mineral occurs principally in the Consols Mine, where it has been found in masses sometimes weighing over a ton: it has frequently been mistaken for native silver. Photographs of some of these large masses are exhibited on the pillar close by. The Museum collections include a large block, which is not publicly exhibited. It occurs associated with calcite and chalybite, together with pyrargyrite, cobaltite, &c. (**8580**, **6905**, and others). An antimonial silver-chloride ore, found in this mine, has undoubtedly resulted from the alteration of dyscrasite—**5233**, **5295**.

8765, **8769**, Consols Mine; pyrargyrite.

1358, Consols Mine; sternbergite, associated with calcite and chalybite.

5497, Consols Mine; fahl-ore, associated with galena and chalybite, and assaying 6,500 oz. silver per ton.

7587, Consols Mine, stromeyerite.

Iodargyrite, iodide of silver,† is generally found as a very soft, waxy, lemon-yellow encrustation on kaolin or ironstone.

5527, Block 11, best shows the crystalline form, the six-sided prisms being very apparent; one of the larger crystals

* A fine specimen (**5206**) of native silver welded on to native copper, from Lake Superior, will be found in case 84.

† The iodine, in iodargyrite, and the bromine in embolite, can be readily expelled and rendered visible by surrounding a fragment of the mineral with bisulphate of potash, and fusing it in a glass tube closed at one end.

measures an eighth of an inch across. The pretty blue quartz **Case 59.** entangled in the ironstone on which these crystals occur should be noted. 5545 shows a great many six-sided prisms, but is dull and opaque-looking.

Of the kaolin-specimens, 48, with its thick masses of iodide, will be noticed. Of the ironstones, it may be said that they sometimes contain the silver minerals right through their mass, or on every side, not only on the surface exposed to view. Other minerals associated with the iodide are cerussite (1362) and calamine (1060—the colourless mineral). Further specimens, and in particular 3116, Central Mine, will be found in **case 127**.

Embolite; chloro-bromide of silver. This mineral is of a bright green colour when first exposed, but rapidly blackens unless kept in the dark. Many of the early specimens have been ruined in this way.* The Museum possesses a fine collection of this beautiful mineral. At Broken Hill it is generally found in waxy-looking little crystals, showing faces of the *cube*, with the angles truncated by those of the *octahedron*. 5531 is a magnificent specimen of manganiferous ironstone on which are seated numerous very perfect crystals of embolite sometimes measuring nearly a quarter of an inch across. 5528, 5530, and others, are spongy masses of embolite. Embolite is also found encrusting or associated with quartz (4102), kaolin (4061), cerussite (1378), calamine (1198, 1147), azurite (1200), galena (1196), malachite (1230).

In the first half of this case are exhibited ores from Silverton, **Case 61.** Thackaringa, Umberumberka, and other localities in the Barrier Range, worked in the early days of silver-mining in this district, but now for the most part abandoned. The ores consist principally of galena and cerussite but rich chlorides or chloro-bromides sometimes occur.

Thackaringa.—Galena, pyrites (iron and copper), blende chalybite, cerussite and quartz occur. The peculiarly fine-grained character of the galena should be noted (1475).

* Photographers will remember that their art depends upon the action of light upon certain silver salts, such as the bromide and chloride.

Case 61. *Silverton.*—Many of the specimens from the various Silverton mines show chloride of silver richly, but this has usually long since blackened to such an extent as to almost escape notice. **1395**, New Year's Mine: an ironstone showing a coating of blackened chloride, and assaying 2,300 oz. of silver per ton. **1399**, Nolan's Mine: similarly shows the chloride on cerussite. **1420**, Mascotte Mine: a mass of blackened spongy chloro-bromide in ironstone. **9401**, Lake's Camp: shows chloro-bromide abundantly in cerussite.

Umberumberka.—The ore here consists of galena, sometimes exceedingly fine-grained and with a fibrous structure (**1445**), with chalybite and cerussite. Native Silver is not uncommon. **6706** is a characteristic specimen showing galena and buff-coloured chalybite, with native silver dusted over the former, or occupying cavities. **1031**, in case **125**, is similar in character. Cerussite sometimes occurs as dusky crystals seated on fine-grained galena (**1484**); at other times it is massive (**1496**).

1389, War Dance Mine, is traversed by veins of silver chloride, the assay value being very high.

8297, Mount Gipps: a bismuth-bearing ore, assaying 4,000 oz. silver per ton.*

From the Pinnacles comes a galena ore associated with garnet (**1476**), and hornblende with magnetic pyrites (**8291**).

1599, Night Dream Mine, in case **125**: chloride ore.

Western district.

Various silver-lead ores from Liddleton, near Hartley, Mount Werong, Wiseman's Creek, Rockley, &c., are exhibited; few, if any, of these are now being worked. In the gossan from the Lewis Ponds Mine (now abandoned), near Orange, native silver (**8270**, **5392**) and silver chloride (**8271**) have been obtained.

* Other instances of the association of silver with bismuth are the Jingera and Duckmaloi ores respectively (see pages 53, 57, and case **60**).

Sunny Corner.—The gossan contains native silver in an exceptionally finely divided form (1530), and often becomes stalactitic (1529). Beneath the gossan comes a siliceous mixed sulphide ore (8267-8-9). **Case 60.**

Bobadah, Overflow Mine.—Copper and lead minerals (cuprite, 7621; cerussite, 7619; galena, 7726) occur above water-level. The sulphide ore is siliceous and contains much pyrites (7727).

Cobar District.—Silver minerals are sometimes associated with the gold-bearing slate. 4072, from Billagoe, show chloro-bromide; while 8938, from the 120-ft. level, Great Peak Mine, Cobar, shows the same mineral abundantly. Ruby silver has been found at Drysdale (8974, case 54).

9129, Chesney Mine, Cobar, in case 125: quartz showing silver chloride and free gold.

1524, Adelong Creek: galena associated with magnetic pyrites, assaying 28 oz. silver and 8 dwt. of gold per ton, and closely resembling some of the ore from the Pinnacles Mine (8291, case 61). Southern district.

Jingera, Whipstick.—Here the ore consists essentially of a decomposing granite impregnated with bismuth sulphide. 8566 shows an abundance of the bismuth sulphide—the grey mineral; it assays 900 oz. silver per ton and 18½ per cent. of bismuth.* A good deal of molybdenite occurs in the granite: it can be well seen in 8383, where it has a bluish tint by contrast with the grey-black bismuth sulphide. Silver chloride has been found here (1522).

8557, Moruya Gold and Silver Mine: rich arsenical pyrites and galena.

Bredbo.—Silver-lead ores.

Captain's Flat.—See also Copper, case 63.

Boro.—Silver-lead ores.

* Only a very small patch of this ore was found.

Case 60. *Yass.*—1508, galena in fluor (the colourless mineral). 8247 shows galena altering into cerussite, the latter mineral forming concentric rings round the former.

5826, Belconon (Murrumbidgee): A galena ore carrying a very little silver is exhibited because the matrix is felsitic.

Grenfell.—Great Southern Mine. 7329 contains phosphate of lead, to which the yellow colour of the specimen is due. 8246, massive carbonate of lead, appears from its structure to have resulted from the regular alteration of galena.

Wallah Wallah, Rye Park.—See also pyromorphite specimen 8578, in case 62.

Burraborang.—This silver field is nearer to Sydney than any other. The lodes occur in a mass of porphyry outcropping in the valley, beneath a mountain of Permo-carboniferous and Triassic strata. The ore consists of galena with arsenical pyrites, chalybite, &c.

9654, in case 128, is a section across the lode at the Yerranderie mine; it shows the parallel arrangements of the mineral constituents extremely well.

9304 shows native silver on galena.

10021, the Peaks Mine: native silver on galena with mispickel and copper pyrites. The galena assays 170 oz. of silver to the ton.

10148, the Peaks Mine: pyrargyrite.

10205, Yerranderie Mine: a magnificent specimen of leafy native silver.

Case 62.

LEAD.

No mining for lead alone is carried on in this State, the whole of the output being from the silver mines. The true lead ores will therefore be found under the heading "Silver." In this case are exhibited a number of well-crystallised lead minerals. The variety of colouring and appearance and the great beauty of some of these minerals are very striking. Other lead minerals such as the magnificent red chromate, not known to occur in

New South Wales, will be found in **case 82**. Large specimens **Case 62** of galena, cerussite, and pyromorphite are placed in **case 46** near the entrance.

Lead minerals are all very heavy, and can be in every case readily scratched with a knife-blade.

Cerussite—carbonate of lead (PbCO_3): a colourless transparent mineral with a lustre approximating to that of the diamond. From the Broken Hill Silver Mines have been obtained in abundance some of the very finest specimens of cerussite ever found; unfortunately, they are very fragile, so that it is very difficult to safely transport some of the more delicate varieties. The beautiful arrow-headed twin crystals* are particularly noteworthy (4107, 7585; Plate II).

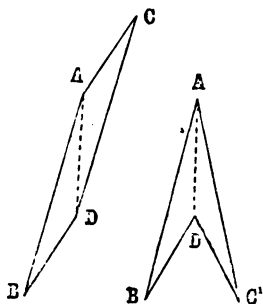


Fig. 1

Fig. 2

7585, Block 11, Broken Hill, shows arrow-headed twins coated with small crystals of anglesite—sulphate of lead.

Crystallised cerussite is also found at Mount Costigan (see **case 125**) and Lewis Ponds (8272), while massive cerussite is of very common occurrence.

5552, Broken Hill, admirably illustrates the replacement of one mineral by another (*pseudomorphism*). The specimen now consists of cerussite with cubical interspaces; originally it was lead sulphide (galena), but the action of water holding carbonic

*The formation of these twin crystals may be illustrated by cutting out a piece of paper similar to A B C D (Fig. 1), and then dividing it along the broken line A D. By turning the A D C portion completely round so that C comes to C' (Fig. 2), an arrow-headed form results. It must not be understood that such a rotation has actually taken place; but the molecules of one portion of the twin are reversed with regard to those of the other.

Case 62. acid in solution has gradually converted it into lead carbonate, the action taking place most actively along the cubical cleavage cracks off the original galena. At a later date carbonate of copper was deposited superficially.

Anglesite, sulphate of lead: a colourless mineral with high lustre, in many respects resembling cerussite in appearance. The specimens exhibited come almost entirely from Broken Hill. Anglesite is often founded seated on cerussite. **Case 46** contains a very fine specimen from Block 14.

Pyromorphite, phosphate and chloride of lead: frequently yellow; the crystals form characteristic six-sided prisms with flat terminations. Unlike galena and cerussite, this ore of lead seldom carries silver. The mineral occurs in a number of localities, the best crystals coming from the Mount Stewart Mine, Leadville, from Broken Hill, and from the Wallah Wallah Silver Mine, Rye Park.

1545, Mount Stewart: greenish-yellow crystals showing the characteristic form; two exceptionally fine specimens from here will be found in **case 46** (Plate III).

1220, Block 14, Broken Hill: yellow crystals. **1040**, Block 14, Broken Hill, shows hollow crystals. **806**, Cobar: on slate. **8737**, Goulburn: on ironstone.

5711, typical of a massive yellow variety not uncommon in the Braidwood district; it has the following composition:—

Lead oxide	...	...	...	69·40
Lead	...	...	...	6·57
Phosphoric anhydride	...	...	...	15·22
Chlorine	...	...	...	2·26
No gold or silver.				

A less common variety (**5521**) is found at the Junction Mine, Broken Hill. It occurs in fragile clusters of crystals of an ashen colour. **Case 46** contains two very fine specimens of this variety.

8578, Wallah Wallah Mine, is somewhat similar to the pre-Case 62. ceding: it consists of elongated, slightly tapering crystals.

7583, case 127 Junction Mine, Broken Hill; a massive botryoidal form.

Phosgenite, chloride and carbonate of lead: a rare mineral.

7586, Broken Hill.

Mimetite, arseniate and chloride of lead: a mineral closely resembling pyromorphite, but containing arsenic in place of phosphorus. Some small specimens from Broken Hill are exhibited.

Orcoisite, chromate of lead: one inferior specimen, believed to have been found in New South Wales.*

Vanadate of lead—1226, Consols Mine, Broken Hill: an earthy specimen.

Wulfenite, molybdate of lead: a beautiful mineral, generally of a brownish-red colour.† Several specimens from the Proprietary Mine, Broken Hill, are exhibited.

8225, Wyalong: contains specks of a mineral that may be wulfenite.

Stolzite, tungstate of lead: a rare lead mineral found at the Proprietary Mine, Broken Hill. A massive form of stolzite, associated with scheelite, occurs at Cordillera Hill, Mount Costigan.

Tungstate of lead is a striking instance of the same chemical compound crystallising in different forms—*polymorphism*. It is difficult at first to realise that the varieties of stolzite exhibited here all have the same chemical composition.

5905, 5929, 6484: claret-coloured, pyramidal.

5517: ash-coloured; the crystals have the form of an elongated square prism terminated by a flat four-faced pyramid.

5513, similar in appearance to the foregoing, only the prism is short, giving the crystal a nail-head aspect.

* Magnificent crocoisite from Tasmania will be found in case 90.

† Honey-yellow crystals, from Arizona, will be found in case 82.

Case 62. 5573, colourless, with a brilliant lustre: the crystals form square plates.*

Galena, sulphide of lead: one of the commonest of metallic minerals, and frequently found in ore deposits; many of the ores in the gold and silver cases consist of *galena*. The specimens exhibited here are selected on account of their showing crystal form or some other special characteristic.

Galena commonly crystallises in cubes, the angles of which are frequently truncated by faces of the octahedron (see fig. C, p. 72). The cleavage is extremely perfect and cubical. On tapping a piece of crystallised *galena* with a hammer it will fly to pieces, each having a cubical form and capable of being still further subdivided. The characteristic cleavage can often be seen in hand specimens. This, together with the leaden colour of the mineral and its streak, and the ease with which it can be cut (*sectility*), renders the identification of *galena* exceptionally easy.

1446, Broken Hill, and a cube cleaved from Boorolong *galena* show the cubical cleavage well. 6535, in case 46, is a fine specimen of the Boorolong mineral.

Occasionally *galena* crystallises in eight-sided pyramids (*octahedra*), this is shown by 9171 from Tingha District, and by 4191 (in case 46) from White Rock. 1059, Consols Mine, Broken Hill: shows the *cube* and the *octahedron* occurring in combination, as mentioned above.

1074, Proprietary Mine, Broken Hill: a curious cauliflower-like form.

6697, Broken Hill, shows *galena* undergoing transformation into carbonate of lead. (See above.)

5565, Consols Mine, Broken Hill: *galena* partially replaced by compounds of antimony with chlorine and vanadium.

8418, Day Dream Mine, Barrier Range: an earthy yellow oxide of lead.

For antimonial lead ores see Antimony, case 68.

* Regarded as a distinct mineral species.

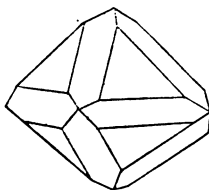
COPPER.

The collection of copper minerals and ores from New South Wales is contained in show-cases 63 and 65. They are arranged in districts in the following order:—Broken Hill, Northern, Southern, Western.

Although not a copper-mining district, a considerable variety **Case 63.** of copper minerals occurs at the Broken Hill silver mines. **Broken Hill.** Argentiferous copper ores will be found among the Broken Hill silver ores in case 59.

Native copper, occurs in great variety of form, more particularly at the Proprietary Mine, and many fine specimens are exhibited. The mineral crystallises in *octahedra* (see page 68), but the faces are generally very irregular,—well shown in 5486. Frequently a number of crystals are superposed upon one another giving rise to tree-like (*arborescent*) forms, like 1176, or to confused masses. Fragments of other minerals may be entangled with the native copper, *e.g.*, cerussite (1162). Crystals of colourless pyromorphite can be seen on 1846.

Cuprite, red oxide of copper.* In its massive form, red oxide of copper was commonly found in the upper levels of some of the mines (1764). It is sometimes argentiferous. The mineral crystallises in *octahedra*, these being sometimes very perfect. The sharp triangular faces on 5473 will be readily seen. The crystals in 1859 show faces of the *rhombic dodecahedron*, as well as the *octahedron*.



Cuprite crystal.

(Rhombic dodecahedron modified by octahedron.)

* When bruised or powdered, cuprite is of a red colour closely resembling that of ruby silver.

Case 63. 8472, from the Proprietary Mine, is undergoing transformation into carbonate of copper.

Azurite, hydrated blue carbonate of copper. Azurite crystallises in complicated crystals belonging to the monoclinic system. It very commonly occurs in good crystals, often of a tabular habit. Some very beautiful specimens have been found at Block 11.

5155, a large tabular crystal.

5480, a group of tabular crystals, each radiating approximately from the centre of the group.

5478, numerous small tabular crystals, quite similar to 5155.

5479, shows azurite altering into malachite while still retaining its crystalline form (*pseudomorphous replacement*).

A beautiful specimen of azurite from Block 11 will be found in case 43, near the door.

Malachite, hydrated green carbonate of copper.* Malachite is not so commonly found crystallised as azurite, and none of the specimens exhibited show distinct crystal form. Case 43 contains a large block of malachite.

Chrysocolla, hydrated silicate of copper. 6698, North Mine.

Marshite, iodide of copper. This is a very rare mineral, so far only found at Broken Hill, in which copper and iodine are combined together forming salmon-coloured crystals with triangular faces. 1057, Proprietary Mine: shows numerous crystals of marshite lining the sides of irregular cavities.

Nantockite, chloride of copper: a waxy white mineral. Unfortunately, nantockite is rapidly acted upon by the atmosphere and converted into an earthy green compound; attempts at satisfactorily preserving it have so far failed.

Atacamite, hydrous chloride and oxide of copper: a pretty dark-green mineral. 1856, a small crystallised specimen. The

* Malachite contains a smaller proportion of copper than azurite.

green alteration of *nantockite*, just mentioned, may be regarded **Case 63.**
as *atacamite*.

Copper pyrites, yellow sulphide of copper and iron. This mineral is the most important ore of copper. It can generally be readily distinguished from iron pyrites by a difference in the shade of its yellow colour and by its inferior hardness.*

Covellite, an indigo-blue sulphide of copper. 1273, Consols Mine. 9990, near Broken Hill: covellite resulting from the alteration of copper pyrites.

The copper deposits here are not of much importance, and but few specimens are shown. Northern District.

1838, Upper Bingara: rich black sulphide ore.

1876, Bobby Whitlow, Bingera: rich copper pyrites.

9104-5, Mount Carrington, Drake: pretty little octahedral crystals of cuprite (see p. 59), with edges and angles modified by other forms of the cubic system.

6417, Willi Willi, Macleay River: carbonate ores assaying 33 per cent. copper and 21 oz. silver per ton. 4565, in case 43, is a fine block of blue carbonate ore from this mine, assaying 49 per cent. of copper and 118 oz. of silver per ton.

9156, Chandler River, Hillgrove: encrustations of hydrous silicate of copper (chrysocolla).

7710, Bundarra: peacock ore and bornite, assaying 25 per cent. of copper—a lower assay than the appearance of the ore would suggest.

Peacock ore is a tarnished variety of copper pyrites, showing peacock tints on the surface.

Bornite is a sulphide of copper and iron containing a higher percentage of copper than copper pyrites does; it is always massive, and while breaking with a bronzy-coloured surface of fracture, rapidly tarnishes to a deep purple.

8421, Bald Hill, Emmaville, native copper in fluor.

* Copper pyrites can be scratched with the point of a knife; pyrite cannot.

**Southern
District.**

Although numerous deposits occur in this district, there are none of any special importance. The Captain's Flat (Lake George) Mine is well represented.

6745, leafy native copper, with arborescent (plant-like) growths.

6744, hydrous sulphate of copper; the "bluestone" or "blue vitriol" of commerce when artificially prepared. It is not an original mineral, but always results from the solution of copper from the ore by percolating water and its re-deposition in cavities or even upon the timbering of old mine workings.*

1238, from the 360-foot level in the Lake George Mine, indicates the general nature of the ore—an intimate mixture of copper and iron pyrites with zinc blende.

For other ores from this mine, see under **Silver, case 60.**

9117, Snowball Mine, Gundagai: rich copper pyrites in chlorite schist.†

9087, Jones Creek, Gundagai: clay-slate, with a thin film of native copper.

6884, in case 126, from the chrome mines at Gundagai, shows chrysocolla (hydrous silicate of copper), with serpentine and chlorite.

Peelwood, native copper, 1754, 1755; azurite crystallised with cerussite, 1779; malachite, showing the characteristic mammillated form, 1797.

9111, Tuena: weathered schistose rock, with sulphates of iron‡ and copper, assaying 9 dwt. of gold per ton and 20 per cent. of copper.

1832, Brungle: copper pyrites in chlorite schist.

* The occurrence of blue vitriol, while proving the existence of copper ores, in no way indicates that these are rich. The ore may be distributed through the rock in very small quantity; but, given sufficient time, water will dissolve out enough to make a deposit of copper minerals.

† Chlorite schist is a metamorphic rock, not uncommonly associated with copper ores in New South Wales.

‡ A secondary mineral, resulting in the same manner as bluestone.

PLATE III.



CRYSTALLISED PYROMORPHITE, MOUNT STEWART.



Cooma; 8531, Dartmoor Mine: gossan from a depth of 20 feet, assaying 24 per cent. of copper, $12\frac{1}{2}$ per cent. of lead, 51 oz. silver per ton. Rich copper pyrites ores from the Fiery Creek Mine are shown.

10052, Lobb's Hole Mine, Yarrangobilly: copper pyrites. **Case 65.**

COBAR.—This important Copper Field is represented by a variety of specimens, some of great beauty, both in this case and in upright **case 43** at the lower end of the room, where the larger ones are placed. The country rock of the district is essentially clay-slate,* and is frequently very ferruginous (8931). Generally speaking, very little copper was showing in the lode at the surface. 8940 represents an outcrop of slate charged with copper carbonates. The outcrop is sometimes siliceous (8941). 8939, raddle (earthy oxide of iron), is taken from a native well on the outcrop of the lode.†

Western District.

Native copper occurs in small quantities in the upper levels. 1753 and 2854 show arborescent forms. See also 1747 in **case 43**. 1843 shows films of native copper between the partings of the slate.

Cuprite, red oxide of copper, occurs both massive (8176) and crystallised (1761, 1766). The crystals form *octahedra*, with angles and edges modified by faces of the *cube*, quite similar to those from Broken Hill.

Azurite and *Malachite*.—Beautiful specimens of these minerals occur above water-level at Cobar. The crystals of azurite (1787 and in **case 43**) are quite as well formed, if not quite so large, as those from Broken Hill (**case 63**). The malachite is the best found in New South Wales, but generally appears in silky aggregates not suitable for polishing. The finest specimen is the large one in a special case close by.

1809, slate breccia, cemented together by crystallised copper carbonates.

* It is frequently the case that copper ores are associated with igneous rocks; this is not so at Cobar.

† The aboriginals used the raddle as a pigment, and "Cobar" is claimed by them as their name for the material.

Case 65. 1799 was originally quite like 1794, but was partially converted into oxide, while still retaining its crystalline form, at the great fire which destroyed the museum collections in 1882.

3936, a nodule of azurite that has been cut and polished to reveal the concentric and radial structures better: it would be an attractive ornamental stone.

Sulphide Ores.—The sulphide ore found beneath water-level consists of copper pyrites and copper glance,* principally the former.

8936 shows veins and patches of copper pyrites in a dark-green slate.

NEW MOUNT HOPE.—*Cuprite, azurite, and malachite* occur as at Cobar, and are sometimes well crystallised (1793 and a fine mass of azurite crystals kindly lent to the Museum.) The country rock is somewhat similar to that at Cobar, but the ore occurrence is different.

1785, bleached country rock in more or less parallel strings.

1793, malachite in sandstone.

1833, copper pyrites.

GIRILAMBONE.—Here, as at New Mount Hope, the ore occurs, not in true lodes, but in veins traversing the slates† and sandstones of the country. 9152, slate traversed by irregular veins of copper pyrites. 8924 and 8925, in upright case 128 near the entrance, show the copper ores (carbonates and sulphides respectively) deposited between the separation faces of the schistose country rock. Native copper (1558), malachite (4177), and azurite (1776) occur above water-level.

Nymagee.—The massive character of the ores will be noted:—Cuprite (8177), copper glance (1837), copper pyrites (6967).

* *Copper glance or redruthite* contains copper combined with sulphur, and is a richer ore than copper pyrites. It is a massive mineral, breaking with an even fracture, and frequently escapes notice as a copper ore owing to its black colour. It can be readily identified by the ease with which small shavings may be cut from it with a penknife, leaving a shining surface (*sectility*).

† The slates have sometimes been transformed into schists.

Overflow Mine, Bobadah.—Small quantities of cuprite and **Case 6.** azurite occur in the upper levels.

8188, Goodrich Mine, Yeoval: a siliceous copper-pyrites ore with molybdenite—the plumbago-like mineral—and chlorite. Copper glance occurs also at this mine (1825).

Blayney.—Native copper (1756), red oxide (1773), black oxide (1840), green carbonate (1805), copper pyrites (1823).

Carcoar.—9274, from the old Coombing Mine, shows copper pyrites with magnetic iron pyrites—the bronzy mineral.

Woodstock.—The rich bunch of ore found at the Burley Jacky Mine is represented by 820 (bornite) and 8180 (peacock ore). 1163, in gold-case 52, shows free gold on bornite from this mine.

Tuglow, Burruga, Cow Flat.—Rich patches of ore have occasionally been found in the Jenolan District. 8788, from Hampton, is chlorite*, containing bornite and tourmaline; the association with tourmaline is most unusual.

Eugowra, Condobolin, Cargo (Dolcoath Mine), Parkes.—7985, 16 miles N.W. of Parkes, is specially exhibited, because it illustrates a frequent mode of occurrence of copper ores in the western districts of the Colony, viz., in the volcanic rock called andesite. 7985 is a dark purple andesite, with conspicuous crystals of felspar in one portion. Epidote† is also present in considerable quantity. For comparison with the valueless epidote, a piece of true green carbonate of copper is placed in the same tray.

Walli.—3817 is an altered basalt (melaphyre), with specks of native copper. The occurrence is of no commercial value, but it is of interest in being analogous with that of the Lake Superior Mines (case 84, see page 110).

Orange.—

* The dark green chlorite was at first taken for carbonate of copper.

† Epidote, a greenish-yellow mineral, frequently resulting from the intense alteration of igneous rocks such as andesite. It is sometimes found showing specks of native copper, but in no known case is it of value as an ore of copper.

Zone II — The zone is about 100 ft. thick and is mostly composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone III — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone IV — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone V — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone VI — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone VII — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone VIII — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone IX — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone X — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone XI — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone XII — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

Zone XIII — This zone is about 100 ft. thick and is composed of sand and silt with varying amounts of gravel. It is the greatest zone of the section and is the most important.

2000

2100

2200

2300

2400

2500

2600

2700

2800

2900

3000

3100

3200

3300

3400

3500

3600

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3800

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4000

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4500

4600

4700

4800

4900

5000

5100

5200

5300

5400

5500

5600

5700

5800

5900

64.

New England

imens.
abundant

Case 65. Bathurst Co.—9365, Parish Malongulli, is yet another instance of andesite carrying copper ores.

Wiseman's Creek.—The ore here occurs impregnating a talcose schist. A fine block specimen will be found in the end compartment of **case 61**. Labels, giving partial analyses, will be found accompanying the sulphide ores.

Molong.—8182, carbonate ore from Gumble; from a deposit containing varying amounts of tinstone. 1774, Gowonglah, is the only good specimen of the hair-like variety of red oxide of copper (chalcotrichite) from this State in the collections.

Bogan, Beemery, Gilgunnia, Mount Gipps, Silverton, Nuntherungie.

TIN.

But few tin-bearing minerals occur in Nature, and of these only two are at all common, viz., *cassiterite* or *tinstone*, the oxide of tin, and *stannite*, a sulphide of tin, copper, and iron. The former only is used as an ore of tin.

Tinstone is a heavy mineral, generally blackish in colour, but sometimes resinous and of a reddish tint or even creamy. The crushed ore is more or less buff in colour (streak), no matter how black the mineral itself may be. Tinstone is harder than the best steel, so that it is quite impossible to scratch it with a knife. The hardness, density, and streak are of great assistance in identifying the mineral. The colour of the powder alone should prevent the common error of confusing it with titaniferous iron ore, which has a black streak. Other minerals sometimes mistaken for tin ores, such as wolfram and tourmaline, will be referred to later. Like gold, tinstone may be mined either in its parent rock, or in alluvial deposits arising from the destruction of the tin-bearing rock by denudation; it is then known as *stream tin*. Of these the alluvial deposits are by far the richer, much of the rock, being lighter than the ore, having been carried away by the running water. In every tin-mining district

it is the alluvial that is worked first, the lode deposits being followed up later. Although a very small percentage of metal is sufficient to make tin lodes worth working under favourable circumstances, they have not as yet proved very profitable in New South Wales. It is owing to the abundance of alluvial tin, easily worked by cheap Chinese labour, that the production of tin in the East (Straits tin) has become so important.

The collection of ores from New South Wales is very complete: **Case 64.** it is contained in three cases; lode tin in **64**, stream tin in **66**, clock specimens in **126**.

By far the most common parent rock for tin is *granite*. It is **Lode Tin.** not certain to what extent the tinstone has been formed at about the same time as the quartz, felspar, and other minerals of which the granite consists, or has been introduced later by mineral-bearing solutions or vapours. Other minerals similarly formed, and often accompanying tinstone, are beryl, topaz, and tourmaline. Another effect of these mineral-bearing solutions has often been the partial destruction of the granite, more particularly of its felspathic constituent. While tinstone is thus frequently found irregularly distributed in strings and patches through granite, it sometimes occurs with quartz, occupying fissures or otherwise. These and other features of the occurrence of lode tin are illustrated by the specimens in this case.

Deposits of lode tin are always found associated with granite or closely allied rocks. The mineral contents of these lodes—compounds of tin, fluorine, boron, &c.—are believed to have been derived from the magma remaining after the crystallisation of the rock containing them.

Tin ores are widely distributed in New South Wales, but it is **New England.** only in New England that they occur in any abundance. Consequently the greater part of this case is devoted to New England.

The first few columns are reserved for crystallised specimens. Although occasionally good, these crystals are not so abundant or so perfect as those from Cornwall.

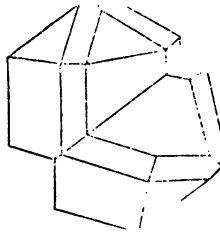
Case 64. 7926, Ottery Lode : an imperfect crystal, showing the characteristic form of tinstone ; it consists of a square prism capped by a square pyramid, all the edges being bevelled.



Crystal of Tinstone, showing prism and pyramid faces with bevelled edges.

1665, 1666, and other specimens from the Yankee Lode, show quartz crystals with tinstone embedded in them. It is evident that the tinstone has formed first, and the silica has crystallised round it at a later date as quartz.

4453, Ottery Lode : shows a twin crystal, a very characteristic mode of crystallisation for tinstone.



Elbow-shaped twin crystal of Tinstone.

7783, Mole Tableland, shows the termination (*i.e.*, the pyramid portion) of a quartz crystal invested by a layer of tinstone half an inch thick. This is a particularly interesting specimen.

Among other places, crystals are exhibited from Deepwater, Emmaville, Oban, Glen Innes, Inverell, Stannifer and Pheasant Creek.

1637, Pheasant Creek: a variety of granite (*greisen*) heavily charged with tinstone. This variety of granite contains much mica (the silvery-white mineral), but practically no feldspar. No doubt the feldspar was destroyed by the same solutions that brought in the tinstone. **Case 64.**

1637, Bismarck Reef, Tingha: granite traversed by a vein of quartz, on one side of which lies a vein of tinstone that has sent offshoots into the granite.

1649, Old Gulf Lode: represents another type of lode tin; in this there are no veins, but the granite rock has been impregnated with the tinstone without appreciable loss of feldspar.

5355, Old Gulf Lode: tinstone associated with much beryl (the pale greenish blue mineral). Several smaller specimens of tinstone with beryl will be found in this case.

1663, Great Britain Mine, Emmaville, is quite another class of stone. The rock is an igneous dyke—quartz-feldspar—somewhat like the elvan of the Cornish tin-mines, and the tinstone coats a joint-face.

1633, Torrington Mine: another instance of feldspathic country rock impregnated with tinstone; small cavities lined with crystals of tinstone will be noticed.

1652, quartz-feldspar-porphry, the country rock of the Ottery Lode.

7964, Wall Creek, Black Swamp: a good instance of rich tinstone with quartz gangue.

7933, The Grampians: a vein of quartz flanked with tinstone on either side.

7936, a 2-inch quartz vein, carrying tinstone, traversing a fine-grained granite: it should be noticed how the quartz crystals have grown inwards from the sides of the fissure without quite filling it up.

Case 64. 1628, Butler Lode: one of the few lode tin deposits that have been worked to any extent. A large block of this ore is exhibited on a table near the door. The tinstone occurs in quartz, and is associated with arsenical pyrites.

1621, Mole Tableland: fine-grained granite (*eurite*) traversed by strings of tinstone.

7958, Torrington Lode: a good instance of a felspathic rock thoroughly impregnated with tinstone.

1649, Ding Dong, near Deepwater: tinstone in greisen.

7955, Bridge Creek: tinstone associated with chlorite—the mineral that gives the deep green tint to the ore.

7948, Back Creek: tinstone with wolfram, which can be easily recognised by its long glistening cleavage faces.*

7949, Emerald Mines, Emmaville: tinstone in quartz, with green beryl (see p. 13 and case 49).

1677, Rockvale, Armidale: large ironstained felspar crystals, in which tinstone is imbedded. •

801, Emerald Mines, Emmaville: crystals of tinstone with fluor in soapstone.

7932, Newstead: tinstone in greisen.

9267, Elsmore: tin-bearing greisen. The ore occurs in pipes from three to four inches in diameter, which do not go down far. Wolfram occurs in the same deposits.

7940, Ph. Swinton, co. Hardinge: granite traversed by very conspicuous veins of black tinstone.

1562-3 and others from the Giant's Den Mine, Bendemeer. The ore here occurs with quartz in greisen, and is interesting from its association with tourmaline. 1562 shows radial groups of dark-green tourmaline.†

* On the presence of wolfram in tin ores see page 72.

† Tourmaline can be distinguished from tinstone by (a) not being so heavy (specific gravity about 3 only); (b) frequently occurring in bundles of needle-like crystals; (c) crushing to a greenish powder; (d) being easily fused before the blowpipe.

Case 65. 1799 was originally quite like 1794, but was partially converted into oxide, while still retaining its crystalline form, at the great fire which destroyed the museum collections in 1882.

3936, a nodule of azurite that has been cut and polished to reveal the concentric and radial structures better: it would be an attractive ornamental stone.

Sulphide Ores.—The sulphide ore found beneath water-level consists of copper pyrites and copper glance,* principally the former.

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1793, malachite in sandstone.

1833, copper pyrites.

GIRILAMBONE.—Here, as at New Mount Hope, the ore occurs, not in true lodes, but in veins traversing the slates† and sandstones of the country. 9152, slate traversed by irregular veins of copper pyrites. 8924 and 8925, in upright case 128 near the entrance, show the copper ores (carbonates and sulphides respectively) deposited between the separation faces of the schistose country rock. Native copper (1558), malachite (4177), and azurite (1776) occur above water-level.

Nymagee.—The massive character of the ores will be noted:—Cuprite (8177), copper glance (1837), copper pyrites (6967).

* *Copper glance* or *redruthite* contains copper combined with sulphur, and is a richer ore than copper pyrites. It is a massive mineral, breaking with an even fracture, and frequently escapes notice as a copper ore owing to its black colour. It can be readily identified by the ease with which small shavings may be cut from it with a penknife, leaving a shining surface (*sectility*).

† The slates have sometimes been transformed into schists.

Overflow Mine, Bobadah.—Small quantities of cuprite and **Case 6.** azurite occur in the upper levels.

8188, Goodrich Mine, Yeoval: a siliceous copper-pyrites ore with molybdenite—the plumbago-like mineral—and chlorite. Copper glance occurs also at this mine (1825).

Blayney.—Native copper (1756), red oxide (1773), black oxide (1840), green carbonate (1805), copper pyrites (1823).

Carcoar.—9274, from the old Coombing Mine, shows copper pyrites with magnetic iron pyrites—the bronzy mineral.

Woodstock.—The rich bunch of ore found at the Burley Jacky Mine is represented by 820 (bornite) and 8180 (peacock ore). 1163, in gold-case 52, shows free gold on bornite from this mine.

Tuglow, Burrage, Cow Flat.—Rich patches of ore have occasionally been found in the Jenolan District. 8788, from Hampton, is chlorite*, containing bornite and tourmaline; the association with tourmaline is most unusual.

Eugowra, Condobolin, Cargo (Dolcoath Mine), Parkes.—7985, 16 miles N.W. of Parkes, is specially exhibited, because it illustrates a frequent mode of occurrence of copper ores in the western districts of the Colony, viz., in the volcanic rock called andesite. 7985 is a dark purple andesite, with conspicuous crystals of felspar in one portion. Epidote† is also present in considerable quantity. For comparison with the valueless epidote, a piece of true green carbonate of copper is placed in the same tray.

Walli.—3817 is an altered basalt (melaphyre), with specks of native copper. The occurrence is of no commercial value, but it is of interest in being analogous with that of the Lake Superior Mines (case 84, see page 110).

Orange.—

* The dark green chlorite was at first taken for carbonate of copper.

† Epidote, a greenish-yellow mineral, frequently resulting from the intense alteration of igneous rocks such as andesite. It is sometimes found showing specks of native copper, but in no known case is it of value as an ore of copper.

Case 65. Bathurst Co.—9365, Parish Malongulli, is yet another instance of andesite carrying copper ores.

Wiseman's Creek.—The ore here occurs impregnating a talcose schist. A fine block specimen will be found in the end compartment of case 61. Labels, giving partial analyses, will be found accompanying the sulphide ores.

Molong.—8182, carbonate ore from Gumble; from a deposit containing varying amounts of tinstone. 1774, Gowonglah, is the only good specimen of the hair-like variety of red oxide of copper (chalcotrichite) from this State in the collections.

Bogan, Beemery, Gilgunnia, Mount Gipps, Silverton, Nuntherungie.

TIN.

But few tin-bearing minerals occur in Nature, and of these only two are at all common, viz., *cassiterite* or *tinstone*, the oxide of tin, and *stannite*, a sulphide of tin, copper, and iron. The former only is used as an ore of tin.

Tinstone is a heavy mineral, generally blackish in colour, but sometimes resinous and of a reddish tint or even creamy. The crushed ore is more or less buff in colour (streak), no matter how black the mineral itself may be. Tinstone is harder than the best steel, so that it is quite impossible to scratch it with a knife. The hardness, density, and streak are of great assistance in identifying the mineral. The colour of the powder alone should prevent the common error of confusing it with titaniferous iron ore, which has a black streak. Other minerals sometimes mistaken for tin ores, such as wolfram and tourmaline, will be referred to later. Like gold, tinstone may be mined either in its parent rock, or in alluvial deposits arising from the destruction of the tin-bearing rock by denudation; it is then known as *stream tin*. Of these the alluvial deposits are by far the richer, much of the rock, being lighter than the ore, having been carried away by the running water. In every tin-mining district

it is the alluvial that is worked first, the lode deposits being followed up later. Although a very small percentage of metal is sufficient to make tin lodes worth working under favourable circumstances, they have not as yet proved very profitable in New South Wales. It is owing to the abundance of alluvial tin, easily worked by cheap Chinese labour, that the production of tin in the East (Straits tin) has become so important.

The collection of ores from New South Wales is very complete: **Case 64.** it is contained in three cases; lode tin in **64**, stream tin in **66**, clock specimens in **126**.

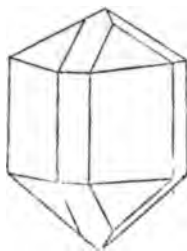
By far the most common parent rock for tin is *granite*. It is **Lode Tin.** not certain to what extent the tinstone has been formed at about the same time as the quartz, felspar, and other minerals of which the granite consists, or has been introduced later by mineral-bearing solutions or vapours. Other minerals similarly formed, and often accompanying tinstone, are beryl, topaz, and tourmaline. Another effect of these mineral-bearing solutions has often been the partial destruction of the granite, more particularly of its felspathic constituent. While tinstone is thus frequently found irregularly distributed in strings and patches through granite, it sometimes occurs with quartz, occupying fissures or otherwise. These and other features of the occurrence of lode tin are illustrated by the specimens in this case.

Deposits of lode tin are always found associated with granite or closely allied rocks. The mineral contents of these lodes—compounds of tin, fluorine, boron, &c.—are believed to have been derived from the magma remaining after the crystallisation of the rock containing them.

Tin ores are widely distributed in New South Wales, but it is **New England** only in New England that they occur in any abundance. Consequently the greater part of this case is devoted to New England.

The first few columns are reserved for crystallised specimens. Although occasionally good, these crystals are not so abundant or so perfect as those from Cornwall.

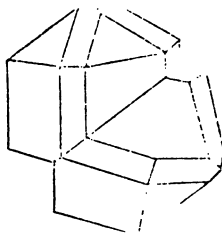
Case 64. 7926, Ottery Lode: an imperfect crystal, showing the characteristic form of tinstone; it consists of a square prism capped by a square pyramid, all the edges being bevelled.



Crystal of Tinstone, showing prism and pyramid faces with bevelled edges.

1665, 1666, and other specimens from the Yankee Lode, show quartz crystals with tinstone embedded in them. It is evident that the tinstone has formed first, and the silica has crystallised round it at a later date as quartz.

4453, Ottery Lode: shows a twin crystal, a very characteristic mode of crystallisation for tinstone.



Elbow-shaped twin crystal of Tinstone.

7783, Mole Tableland, shows the termination (*i.e.*, the pyramid portion) of a quartz crystal invested by a layer of tinstone half an inch thick. This is a particularly interesting specimen.

Among other places, crystals are exhibited from Deepwater, Emmaville, Oban, Glen Innes, Inverell, Stannifer and Pheasant Creek.

1637, Pheasant Creek: a variety of granite (*greisen*) heavily charged with tinstone. This variety of granite contains much mica (the silvery-white mineral), but practically no felspar. No doubt the felspar was destroyed by the same solutions that brought in the tinstone.

1637, Bismarck Reef, Tingha: granite traversed by a vein of quartz, on one side of which lies a vein of tinstone that has sent offshoots into the granite.

1649, Old Gulf Lode: represents another type of lode tin; in this there are no veins, but the granite rock has been impregnated with the tinstone without appreciable loss of felspar.

5355, Old Gulf Lode: tinstone associated with much beryl (the pale greenish blue mineral). Several smaller specimens of tinstone with beryl will be found in this case.

1663, Great Britain Mine, Emmaville, is quite another class of stone. The rock is an igneous dyke—quartz-felsite—somewhat like the elvan of the Cornish tin-mines, and the tinstone coats a joint-face.

1633, Torrington Mine: another instance of felspathic country rock impregnated with tinstone; small cavities lined with crystals of tinstone will be noticed.

1652, quartz-felspar-porphry, the country rock of the Ottery Lode.

7964, Wall Creek, Black Swamp: a good instance of rich tinstone with quartz gangue.

7933, The Grampians: a vein of quartz flanked with tinstone on either side.

7936, a 2-inch quartz vein, carrying tinstone, traversing a fine-grained granite: it should be noticed how the quartz crystals have grown inwards from the sides of the fissure without quite filling it up.

Case 64. 1628, Butler Lode: one of the few lode tin deposits that have been worked to any extent. A large block of this ore is exhibited on a table near the door. The tinstone occurs in quartz, and is associated with arsenical pyrites.

1621, Mole Tableland: fine-grained granite (*eurite*) traversed by strings of tinstone.

7958, Torrington Lode: a good instance of a felspathic rock thoroughly impregnated with tinstone.

1649, Ding Dong, near Deepwater: tinstone in greisen.

7955, Bridge Creek: tinstone associated with chlorite—the mineral that gives the deep green tint to the ore.

7948, Back Creek: tinstone with wolfram, which can be easily recognised by its long glistening cleavage faces.*

7949, Emerald Mines, Emmaville: tinstone in quartz, with green beryl (see p. 13 and case 49).

1677, Rockvale, Armidale: large ironstained felspar crystals, in which tinstone is imbedded. •

801, Emerald Mines, Emmaville: crystals of tinstone with fluor in soapstone.

7932, Newstead: tinstone in greisen.

9267, Elsmore: tin-bearing greisen. The ore occurs in pipes from three to four inches in diameter, which do not go down far. Wolfram occurs in the same deposits.

7940, Ph. Swinton, co. Hardinge: granite traversed by very conspicuous veins of black tinstone.

1562-3 and others from the Giant's Den Mine, Bendemeer. The ore here occurs with quartz in greisen, and is interesting from its association with tourmaline. 1562 shows radial groups of dark-green tourmaline.†

* On the presence of wolfram in tin ores see page 72.

† Tourmaline can be distinguished from tinstone by (a) not being so heavy (specific gravity about 3 only); (b) frequently occurring in bundles of needle-like crystals; (c) crushing to a greenish powder; (d) being easily fused before the blowpipe.

PLATE IV.



CRYSTALLISED PYRITE, MOUNT STEWART.

165, in case 126, is tinstone that has replaced some other mineral—probably calcite—while still preserving the original crystalline form of the latter (*pseudomorphous replacement*). **Case 64.**

4193, in case 126, is a large specimen of crystallised tinstone from New England.

While New England is the principal tin-field, tin ores are found in many other localities.

In the West, tin has been found at Eremeran, in the Cobar **Western** district. (8586, stream tin; 7967, New Mount Hope, lode **Localities.** tin.)

At Euriowie, in the Barrier Range, tin mines were at one time opened in a mass of pegmatite consisting largely of coarsely-crystallised quartz and mica. The ore is associated with tourmaline, and it is frequently very difficult to distinguish between them without applying tests (see page 70). 1603, in case 126, shows tinstone and tourmaline together, while 1605, in the same case, shows the tourmaline well. 7970, Poolamacca, contains white mica and quartz; tinstone is freely shown.

Numerous samples of stream-tin have been found in the **Southern** creeks draining the granite area of the south-eastern portion **Localities.** of the State.

Stream tin believed to come from the following districts is exhibited:—Tumut, Tumbarumba, Dora Dora, Monaro, Narrier, Meadow Flat, Boro, Tarago, Grenfell, Bega, Tantawangle, Bombala, Pullitop, Toolong.

9716, ironstone, Monaro: this assays 40 per cent. of tin. The concentrates contain zircon.

4111, Tumbarumba: stream tin associated with pebbles of andalusite, large specimens of which will be found in case 100. Andalusite has no commercial value (see page 153).

6705, said to come from Wyalong.

10123, 10125, Buddigower, near Wyalong: lode-tin ore, with quartz and arsenical pyrites, in granite. Picked pieces of the

Case 64. tinstone are of remarkable purity and exceptionally low specific gravity (very slightly above 6). (For a large specimen, see case 126.)

7977, Jervis Bay : deposits of tin-bearing beach-sand such as this occur at several places along the coasts of New South Wales.

1872, 7971, and 7241, from Grenfell, Cooyal, and Binda respectively, show the variety of stream tin sometimes known as "toad's-eye."

Deposits of tinstone have been frequently prospected at Pullitop, near Wagga. Unfortunately, both in the alluvial and in the lode, the tin is associated with wolfram, sometimes in almost equal proportions.* (7696.)

**Northern
Localities.**

Another locality where tin deposits have been developed to some extent is Gundle, in the Kempsey district. 1743, 1744 show the stream tin; 1681 the lode. The ore occurs with quartz in granite country. 6729, in the end compartment of case 62, is a beautiful specimen of the Gundle ore, showing green and blue fluor and crystallised quartz.

The auriferous sands of the Northern beaches frequently contain a fair percentage of tin (see page 16). 10203 : tinstone concentrated from sand from the Northern Beaches.

Case 66.
Stream Tin
(New
England)

A large part of case 66 is devoted to the display of stream tin from New England : specimens from other localities have been already referred to. The collection is a very complete one, representing many deposits now worked out. The first half of the case contains stream tin cement, the word "cement" being applied as in the case of alluvial gold (see page 21). Many of the alluvial tin deposits (leads), like those of gold, are ancient water-courses that have been long since filled up, and sometimes deeply covered by the basalt poured down the valleys from the volcanoes that were so active in Australia during the Tertiary epoch of geological time. 3306, Emmaville : pipeclay found

* Wolfram (see page 92) is a valuable mineral in itself, but, owing to its specific gravity being about the same as that of tinstone, the two minerals cannot be separated by washing. Wolfram can be readily distinguished from tinstone, since it can be easily scratched with a knife-blade, while tinstone cannot.

under a cover of basalt, and associated with the tin deposits; **Case 66.** it contains imprints of the leaves of plants not now living in Australia.

1726 and other specimens from Mole Tableland have a ferruginous cement. 1722, from Emmaville, has been transformed into a hard, tenacious rock by the cementing action of silica; it is locally known as "grey-billy."

In a special case, standing in the central passage near here, is a large mass of tin cement from New England.

In case 126 will be found a very rich specimen of the Elsmore cement.

Next in order to the cements are a number of nuggets of tin-stone found in the Emmaville leads, some of which are of great size. Other nuggets, including one from the Elsmore Lead, will be found in case 126.

9088, Elsmore: a portion of a crystal, the edges of which have been rounded. It is easy to understand how continued rolling in the bed of a stream would produce this effect.

Tin-pyrites: sulphide of tin, copper, and iron. An uncommon **Stannite** mineral, needing considerable experience for its sure detection.

9195, Bora Creek (Howell), Inverell: galena, blende, stannite, with quartz—the stannite, in contrast with the other minerals, being recognised by its somewhat greenish tint. The ore is argentiferous.

9556, Bora Creek: almost pure stannite.

IRON (ORES).

This case is reserved entirely for average samples of the known **Case 67.** deposits of iron ores in New South Wales. These deposits are fully described in the publications of the Geological Survey. Each sample is accompanied by a label giving an analysis of the ore and a concise description of the deposit. Bauxite and bauxitic iron ore are included here.

The following deposits are represented in the show-case:—Mittagong (spring deposits), County Camden, Illawarra, County Argyle, Marulan, Goulburn, Queanbeyan, Cudgegong, Fifield, Tallewang, Carcoar, Mudgee, Cullerin, Wallerawang, Newbridge, Cadia, and the aluminous ores of Wingello and Inverell. Also clay-band ore from Capertee.

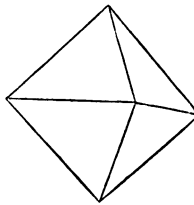
9281, Portion 101, Parish Murrimba, County Camden: pure bauxite, showing the characteristic concretionary structure. It contains 61·46 per cent. of alumina and less than 2 per cent. of iron.

10130, 13135: pisolitic aluminous iron ores from Wingello and Bungonia respectively; these have been cut and polished to show the characteristic structure.

IRON (MINERALS).

Case 69. In this case are exhibited a few picked specimens of the characteristic minerals composed of iron salts. It must be understood that, either from the quantity available being insufficient, or from some defect in quality, none of these minerals can be at present regarded as representing deposits of iron ore.

Magnetite. Magnetic oxide of iron, consisting of *ferrous oxide* and *ferric oxide* combined together; a black heavy mineral, that cannot in general be scratched with a knife blade, and is especially characterised by being more or less magnetic. When crystallised it forms *octahedra* or *rhombic dodecahedra*, but is very frequently massive.



Crystal of magnetite (*octahedron*).

9154, Little Snowball, Major's Creek: rhombic dodecahedral crystals up to one-third of an inch in length of edge.*

* For comparison the fine crystals of similar character from Chillagoe, North Queensland, in case 126 may be referred to.

7797, Goodradigbee River, county Cowley: showing crystal **Case 69**. faces.

Massive specimens are exhibited from various districts.

6685, Broula: a massive variety exhibiting strong polarity. A bar cut from this specimen has been suspended by a thread in **case 125**, and sets itself north and south like a compass needle.

Red oxide of iron in the form of black octahedral crystals. **Martite**. Martite may be an alteration product of magnetite. **6885**, Byng. **2743**, Orange district. **8227**, Parkes district. **7796**, Muttama.

Red oxide of iron. This mineral exhibits great variety in form **Hematite**. and appearance, but is always characterised by its blood-red streak.

1336, Parkes: micaceous variety. **5900**, Kiandra: micaceous variety.

2863, Wellington: replacing fossil crinoid stems.

Massive specimens from Dubbo, Young, and many other localities.

5498, Consols Mine, Broken Hill: pseudomorphously replacing chalybite.

Generally speaking, these are not crystallised, and present great variety in appearance. They are all characterised by the presence of a considerable amount of combined water, and by their yellow or brown streak.

**Hydrated
Brown Oxides,
Limonite, &c.**

4173, Consols Mine, Broken Hill: large pseudomorphs after chalybite, coated with calcite.

3832, **3825**, Barrier Range: pseudomorphs after chalybite.

2891, **2701**, **2711**: stalactitic forms from Piper's Flat, Wal-
lerawang, and from Bulga, near Orange.

7816, near Burragorang: in thin concentric shells.

2734, Ballimore, near Dubbo: mammillated with a black glazed surface.

3077, Fish River Creek: a large cube pseudomorphous after pyrite. (See page 32.)

Case 69. **4082, Bethungra :** with structure somewhat resembling "cone-in-cone." (See page 173.)

2733, Oberon : stalactitic form.

2723, Tingha : hollow concretionary nodule occupied by white clay.

2920, Barrier Range : forming a pseudomorph after chalybite.

4174, Mount Gipps, Barrier Range : pseudomorphous after lenticular crystals of chalybite.

895, Rockley : large cube after pyrite.

2709, Wallerawang : concretionary variety.

7817, Crookwell : fibrous variety.

4083, Pooncarie : oolitic variety.

10139, between Sunny Corner and Piper's Flat : iridescent stalactitic limonite.

Some of the specimens illustrating structural geology in **case 113** consist of limonite.

In compartments at the end of cases **64** and **66** respectively, are block specimens of stalactitic limonite and of limonite pseudomorphous after chalybite from Broken Hill.

In pyramid **case 106** is a mass of bark, stick, &c., encrusted with limonite, from the base of a living rock fern, which was itself partially replaced by oxide of iron ; from Mount Victoria.

The stalactitic, concretionary, and pseudomorphous forms assumed by hydrous oxide of iron are evidence of the facility with which iron salts are dissolved and re-deposited by water.

Chalybite. Carbonate of iron. In small quantities this is not an uncommon mineral. It is sometimes found crystallised, when its cleavage and appearance are not very unlike calcite. Colour, opaque white to buff or red.

There is nothing whatever in the appearance of chalybite to suggest that it contains up to sixty per cent. of metallic iron. The most characteristic test is to gently heat a small fragment in a piece of glass tubing ; the mineral flies to pieces (*decrepitates*) and blackens ; on shaking it out, it will be strongly attracted by a magnet.

PLATE V.



CALAMINE ENCRUSTING STALACTITIC CERUSSITE, BROKEN HILL.



3859, Barrier Range: red chalybite.

Case 69.

4169 and others, Consols Mine, Broken Hill: buff-coloured variety.

8731, Whipstick: white variety.

10258 in case 60, Yerranderie Mine, Burragorang: showing excellent cleavage (some carbonate of magnesia is also present.)

1438, Consols Mine, Broken Hill: shows the characteristic form—the *rhombohedron*.

2764, Cobar Copper Mine: small crystals.

4002, Mandurama: very tiny crystals on country rock.

Hydrous phosphate of iron.

Vivianite.

810, Broken Hill: an earthy variety containing much magnesia.

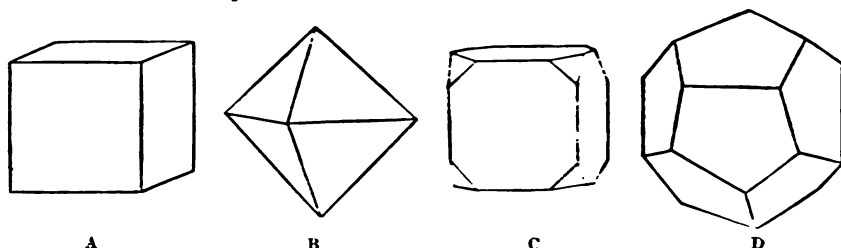
9568, Milburn Creek Copper Mine: good crystals on magnetic pyrites, showing the characteristic blue and green tints respectively when viewed in different directions.

Di-sulphide of iron. One of the commonest of the metallic **Pyrite**. minerals found in lodes. It is the *mundic* of the miner. The appearance of this mineral is too well known to need description; its hardness (above 6) is an important means of distinction from other minerals, more particularly from copper pyrites, since it *cannot be scratched with the point of a knife*.

The pyrites found in lode quartz frequently carries gold: many specimens of such auriferous pyrites are exhibited under **Gold**.

The specimens exhibited here have been selected principally on account of their showing some characteristic, such as crystalline form, well. The most common crystal form is the *cube*. 7661, Major's Creek, shows good cubes, as does the magnificent specimen from Mount Stewart, in a special case near the door. Another common form is the eight-sided pyramid (*octahedron*)—2776. A third, less common form, has twelve five-sided faces (*pentagonal dodecahedron*). A good crystal showing this will be found in **Students' case 33**, against the south wall, and small

Case 69. isolated crystals may often be detected in gold and silver ores, *e.g.*, that from Yerranderie. Burraborang. Sometimes the angles of the cube are cut off by faces of the octahedron, as shown by 1220 from Mount Stewart, and also in case 33.



Crystals of Pyrite.

A. Cube. B. Octahedron. C. Cube, with octahedron. D. Pentagonal dodecahedron.

Very frequently crystals of pyrites become oxidised by exposure to the atmosphere. In this way the sulphur passes off as sulphuric acid, and the iron remains as hydrated oxide, sometimes retaining the crystalline form of the original pyrites most perfectly (*pseudomorphous replacement*).^{*} Several instances of this replacement will be found in the **Gold cases** (see p. 32). The sulphuric acid sometimes found in mine waters, which so quickly corroders iron pipes, arises in this way.

2818, Tibooburra, shows a band of pyrites with a thick crust of oxide.

5188, Wattle Flat, is tarnished, very closely resembling gold. The cubic crystals are, however, very distinct under a lens, and should prevent any mistake.

5470, Bungonia, shows aggregations of cubes forming pretty little rosettes.

9199, Consols Mine, Broken Hill, has a curious surface iridescence.

2816, Mount Macdonald: an irregular piece of chlorite, coated with pyrites on every side.

^{*} The "Devil's dice" of the miners.

Lumps or nodules of pyrites are frequently found in shale and **Case 69.** other sedimentary rocks; these are of secondary origin. (See **4362**, Mount Poole, and **Structure case 113.**)

1373, Thackeringa, illustrates the *slickensides* so frequently met with in mining (see page 173). These slickensided surfaces are often subsequently coated with a thin film of pyrites (see **case 138**), or the pyrites itself may become polished, as in this instance.

3743, Cullen Bullen. Pyrites is sometimes found in small quantities in coal; its presence is highly detrimental.

10158, Lobb's Hole, Yarrangobilly, shows good crystals. This **Marcasite.** form of iron pyrites is characterised by its ready decomposition, and may often be noticed in gold ores, *e.g.*, the Mount Dromedary ore.

Magnetic pyrites differs from ordinary iron pyrites in containing a higher proportion of iron. It is bronzy in colour, and readily attracted by a magnet, whence its name. A massive mineral frequently met with in ore deposits; it is very seldom gold-bearing.

Specimens are exhibited from Blayney, Bolivia, The Pinnacles, Glen Innes, Tent Hill, Macleay River (Willi Willi), &c.

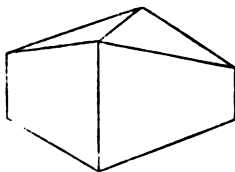
ARSENIC.

Arsenic is used in many ways. It forms the basis of the **Case 68.** sheep-dips used in Australia; and there is some demand for rich arsenical ores.

A black, hard mineral, with a mammillated crust, breaking with a grey, finely-crystalline fracture. **Native arsenic.**

Mispickel: sulph-arsenide of iron; tin-white in colour; frequently emits an arsenical odour when struck with a hammer, and the fumes can be detected by their odour when the mineral is slightly heated. It is frequently associated with the precious **Arsenical pyrites.**

Case 68. metals, and many specimens will be found among the gold and silver ores. Crystals of mispickel are by no means rare; they are characteristic, and easily recognised.



Crystal of arsenical pyrites.

5194, Mount Galena, Emmaville: crystals.

1429, Windeyer, and 1158, Tambaroora: volcanic tuff with crystals of arsenical pyrites.

60, Nambucca: crystals.

Arsenic minerals from other countries, including the sulphides, *realgar* and *orpiment*, which are not found in New South Wales, are exhibited in **case 89** (see page 121).

ANTIMONY.

Ores of antimony are not of uncommon occurrence in New South Wales, but remunerative working has not hitherto been achieved to any extent. Antimony is used in the preparation of certain alloys with lead used for type metal, and other purposes.

**Native anti-
mony.**

A tin-white, crystalline mineral of not very common occurrence. Specimens are exhibited from the Wentworth Mine, Lucknow; the Consols Mine, Broken Hill; the Bellinger River; Deep Creek, Nambucca; Baker's Creek, Hillgrove; and Bukkulla, Inverell. At the Wentworth Mine the native antimony is embedded in calcite, forming pretty mineral specimens; further examples of this occurrence will be found with the gold exhibit in **case 52**. In the Bukkulla specimen (9405) the native antimony is embedded in a nodule of antimonite.

Cervantite.

Earthy hydrous oxide of antimony. A yellowish substance, frequently found as an oxidation product encrusting antimonite.

Specimens from Crudine, Kempsey, Bellinger, Hillgrove, Ash- **Case 68.** ford, Trunkey, Gulgong, Carangula, and Solferino are exhibited. **1556**, from Solferino, shows antimonite within the oxide; evidently the whole mass was once antimonite.

Oxide of antimony. Fibrous crystals from Ulmarra and **Valentinite.** Bowraville. A very similar specimen from Canada will be found in **case 87.**

Oxy-sulphide of antimony; a deep-red fibrous mineral. Speci- **Kermesite.** men from Hillgrove.

Stibnite: sulphide of antimony, By far the most common **Antimonite.** ore. It is a greyish-black mineral, generally occurring in bundles of blade-like crystals. It is very soft, and can be fused by holding a splinter in a candle flame; this easy fusibility affords a ready means of identification. Antimonite is very frequently crystallised—sometimes in needle-like crystals of great delicacy (see **962** and others from Carangula): flat forms with transverse striations, like **966** and others from Hillgrove, are also common and characteristic.

Although nothing comparable to the unique antimonite crystals from Japan (see **special case** facing the entrance) have been found, yet some of the specimens exhibited are very beautiful. **9564**, Hillgrove, and **6915**, Pretty Gully, New England, show a crust of oxide eating into the sulphide. **2844**, Bowra, illustrates the granular form often assumed by the mineral when not distinctly crystallised. Antimonite is sometimes associated with gold ores, or may even be itself auriferous; this is particularly the case at Hillgrove. This association with gold is well illustrated in the gold cases. (See pages 31 and 33.) **985**, Brereton's property, Hillgrove, showing free gold, is exhibited here.

Fahlore: sulphide of copper and antimony. This mineral is **Fahlerz.** placed here for convenience; it would more appropriately be arranged with the ores of copper. Fahlerz does occur crystallised, but there are no specimens from New South Wales in the collection. The ore is frequently argentiferous. The identification of

the mineral requires experience. Specimens are exhibited here from Emmaville, Major's Creek, Molong, and Wiseman's Creek; more will be found with the New England ores in **silver case 58**. It also occurs at the Burragorang Silver Field.

Jamesonite. Sulphide of lead and antimony. A mineral like antimonite in appearance, but often possessing a feathery structure. Specimens are exhibited from Hillgrove, Pye's Creek, and Cullen's Creek (Rivertree). That from Pye's Creek (**6966**) shows the jamesonite forming at the expense of galena, which it is eating into and encrusting.

Berthierite. Sulphide of antimony and iron. A mineral resembling jamesonite. Rivertree and Inverell.

ZINC.

Case 71. Zinc minerals, other than blende, are not common in New South Wales: some, such as the oxide (*zincite*) and the silicates (*willemite*) and (*hemimorphite*), have not yet been detected.

Calamine. Carbonate of zinc* is found very sparingly at Broken Hill and Bredbo, but never in sufficient quantity to admit of its being used as an ore of zinc, as is the case in Spain and elsewhere (see **case 87**, page 112). The mineral is colourless, or of various light shades of green and blue. It is often found in small crystals resembling the so-called *dog-tooth spar* (see calcite, **case 101**, page 156); numerous instances of this will be found among the Broken Hill specimens such as **948**. At other times calamine occurs in crusts or mammillated masses (**4063**). The specimens from Broken Hill are very beautiful. They occur principally lining the interior of cavities (*vughs*) above water-level. A common mode of occurrence is that in which stalactites of carbonate of lead or of oxides of manganese and of iron are studded with little crystals standing out at right angles to the length of the stalactite. Good instances of this will be found in the collections (**5513**, **1865**, Plate V). At Mount Stewart calamine has been found with

* Great confusion exists in the naming of certain zinc ores—the English usage is to call the carbonate *calamine* and the hydrous silicate *smithsonite*; the Americans reverse this order.

carbonates of iron and manganese (949). Calamine also occurs **Case 71.** in the Bredbo district (944, 945.) 7690, Broken Hill, a carbonate of zinc and lime; it has been named *ruleitè*.

Sulphide of zinc; of common occurrence in mineral veins. **Blende** When in deposits of considerable purity it is a valuable mineral—such deposits are not as yet known to exist in New South Wales. The occurrence of blende in ores of gold or silver, gives rise to much difficulty in treating them (see page 43.) Blende may exhibit any shade of colour from amber to black; but notwithstanding this variability, it may be readily recognised by its appearance after some practice. Blende is easily scratched with a knife, the streak being usually buff in colour; the mineral, moreover, has a peculiar resinous feel under the knife: both characteristics are of great value in determination. Good crystals are not common; the best from this State are perhaps those from Spring Creek, Bungonia, (2822, 952), where pale-coloured varieties are sometimes found, and White Rock, Drake (5965).

Some varieties of blende contain a good deal of iron; cadmium is also sometimes present. 9559, Conrad Mine, Bora Creek, contains 22½ per cent. of iron, and a little cadmium.*

COBALT.

The consumption of cobalt in the Arts is not very great; nevertheless, the ores of the metal are of considerable value. Although cobalt minerals are comparatively rare, there is a considerable variety of them. For other ores see **case 89.**

Asbolan: hydrous oxide of manganese containing a variable amount of cobalt; the principal cobalt ore in Australasia. This ore is found in irregular deposits in serpentine at Port Macquarie, from which district several specimens, accompanied by complete analyses, are exhibited; and a block specimen in the end compartment of **case 51.** The contents of metallic cobalt

* The cadmium of commerce is obtained from blende. When present in small quantities it is said to be deleterious.

Case 71. averages about six per cent. The most cobaltiferous varieties sometimes have the beautiful indigo-blue tint seen in 8420.

Similar ores, but not payable, are found in other districts. Near Bungonia it acts as a cement, binding drift-quartz pebbles together (2780 and others).

9018, assaying 2·6 per cent. of cobalt, is from the Union Lead, Forbes (depth of 100 feet).

8993, Tingha, a tin-bearing quartz drift cemented by cobaltiferous wad.

8205, Mount Boppy, assays 2·2 per cent. of cobalt.

8547, Macleay River, assays 6 per cent.

Erythrine. *Cobalt bloom*, hydrous arseniate of cobalt—a peach-coloured encrustation produced by the weathering of cobalt ores. The specimens exhibited are all from the deposit of cobalt-bearing arsenical pyrites—*glaucodot*—at Carcoar. Close inspection shows the encrustation to consist of bundles of needle-like crystals.

Smaltite. Arsenide of cobalt, &c.: A tin-white mineral, characteristic crystals of which will be found in case 89. It has been found in small quantities at the Consols Mine, Broken Hill, associated with chalybite. 1264 shows imperfect crystals.

Willyamite. Sulph-antimonide of cobalt. Consols Mine, Broken Hill.

Cobaltite Sulph-arsenide of cobalt. Consols Mine, Broken Hill.

Glaucodot. Cobaltiferous mispickel: an ore that has been mined in small quantities at Carcoar, and from the alteration of which the erythrine just referred to has resulted.

9305, Inverell, is a cobalt mineral not yet investigated.

7327, stream tin from New England containing cobalt ore.

BISMUTH.

Case 70. Bismuth ores are not uncommon in New South Wales, being found for the most part impregnating, or as pipes in granite. The demand for bismuth is very limited, its use being restricted

mainly to the preparation of alloys with tin and lead, that have **Case 70.** the properties of fusing at a low temperature and of expanding on solidification, and to medicinal purposes. The organisation of the bismuth trade prevents the exportation of more than a limited number of tons of ore annually.

This mineral has a very characteristic appearance, by which it **Native Bismuth.** may be readily recognised with a little experience. A ruddy tinge is often displayed—well shown in the Cobar specimen. It has been found in several localities, but principally on the granite tableland of New England.

Kingsgate, near Glen Innes, yields the greatest quantity of native bismuth, where it is accompanied by molybdenite (see page 87). Numerous specimens of the Kingsgate ore are exhibited here, but the best are in the New South Wales Court of the Imperial Institute, in London.

9077, Kingsgate: shows good cleavage faces with a highly metallic lustre.

1011, Kingsgate: a massive lump of native bismuth with a little quartz; the cleavage faces are coated with carbonate of bismuth.

1012, 1014, Kingsgate: show acicular crystals of native bismuth traversing glassy quartz.

7786, Jingera, Whipstick: granite with native and sulphide of bismuth.

6759, Jingera: somewhat similar to **7786**, but containing much molybdenite, the bluish plumbago-like mineral. This ore assays $10\frac{1}{2}$ per cent. of bismuth and $6\frac{1}{2}$ dwt. of gold per ton.

Further specimens of the Jingera ore, which is sometimes rich in silver, will be found under **Silver 60** (see page 53).

9173, in case 96, Kingsgate: rock crystal, with acicular native bismuth.

1010, Kingsgate: quartz, showing native bismuth and molybdenite very clearly.

- Case 70.** 1015, Kingsgate: granite, showing much native bismuth.
 7412, near Yarrow Creek: white quartz with native bismuth.
 8030 New England: quartz and native bismuth associated with beryl, the pale greenish-blue mineral.
 Specimens are also exhibited from Pheasant Creek, Gragin, Silent Grove, Emmaville, and Binghi.
- Bismuth Ochre.** 1033, 7423, Great Cobar Mine, Cobar, where a little bismuth occurs with the copper ore.
- Bismutite.** Carbonate of bismuth: an earthy yellow substance frequently found encrusting other bismuth ores.
 Specimens are exhibited from Kingsgate, Yarrow, Hogue's Creek, Bingera, Uralla, Severn River, Mount Gipps, and Nanima.
 9706, Warialda District: associated with monazite sand.
 9185, Nanima: concentrates from gold workings.
- Bismuthine.** A block of carbonate of bismuth ore from Kingsgate will be found in case 128, near the door.
 Sulphide of bismuth: generally occurring in clusters of needle-like crystals; closely resembles *antimonite* in general appearance.
 1031, Kingsgate: tufts of fibrous crystals in quartz.
 1040, Kingsgate: with *native bismuth* in quartz.
 8099, Red Range, Glen Innes: in granite, assaying 17 dwt. gold per ton and 13 per cent. of bismuth.
 7326, Nanima: in quartz, assaying 27 dwt. gold per ton and 6 per cent. of bismuth.
 4023, Nimmitybelle: in quartz, assaying $3\frac{1}{2}$ per cent. of bismuth.
 6760, Jingera: granite, with *molybdenite*, &c., assaying 6 per cent. of bismuth, and carrying a little gold and silver.
 9667, Jingera: well crystallized.
 9007, Jingera (in upright case 136, near the door): granite, impregnated with bismuthine and molybdenite.

Sulphide of bismuth, lead and silver. This mineral has been found in small quantities with quartz and copper pyrites at Duckmaloi. Assays of $1\frac{1}{2}$ oz. of gold and 360 oz. of silver per ton have been obtained. **Case 70.** **Cosalite.**

Compounds with tellurium are described under Tellurium.

MOLYBDENUM.

Ores of molybdenum are used in the preparation of certain classes of steel and in the calico and porcelain industries. The value fluctuates, but is at present (1901) very high. The ores are found in granitic rocks for the most part, but occasionally in quartz.

A pretty sulphur-yellow mineral. Whipstick and Nambucca River. **Molybdic Ochre.**

A soft bluish flaky mineral, distinguished from plumbago by the greenish tint of its streak. It occurs at Kingsgate, Bolivia, and many other localities. **Molybdenite.**

9009, Kingsgate: good crystals.

MANGANESE.

Black oxide of manganese (*wad* and *psilomelane*) is of very common occurrence. Such ores are used in the manufacture of steel and the preparation of chlorine.* Numerous samples are exhibited, but it does not follow that they represent workable deposits.

Moonbi, Kempsey, Armidale, Uralla, Nymboida, Bendemeer, Walcha, Tamworth, Gulgong, Mudgee, Glanmire, Cobar, Cooyal, Peak Hill District, Woodstock, Rockley, Eugowra, Caloola, Tumut, Queanbeyan, Cooma, Gundagai.

5265, Bendemeer: contains 96 per cent. of binoxide of manganese.

* For the preparation of chlorine—used in the chlorination of gold ores—it is the binoxide of manganese only that is useful. The amount of binoxide present can only be ascertained by direct determination.

Case 70. 9541, Kempsey: contains 80 per cent. of binocide of manganese.

8964, Murrumbateman: crystallized *pyrolusite*.

Rhodocrosite. Carbonate of manganese. Broken Hill: the rhodocrosite forms globular masses coated with dolomite.

Rhodonite. Silicate of manganese. A pretty pink mineral, capable of taking a good polish.

5494, Block 10, Broken Hill; crystals. Rhodonite occurs in the sulphide ore at Broken Hill. and is sometimes mistaken for garnet.

5353, Bendemeer; polished.

Also, from Tilbuster, Warne River, Manilla, and Bundarra.

CHROMIUM.

Case 73. A considerable quantity of ores of chromium is used in the Arts, more particularly in the manufacture of chrome steel and chemical salts, and for basic linings in furnaces. Chrome iron or *chromite* is the only ore.

Chromite. Chromate of iron: a black mineral, usually massive, that can be just scratched with a good knife. It invariably occurs in irregular masses in serpentine.

In New South Wales chromite has been found in many serpentine areas. Bingera, Barraba, Gordonbrook, Lionville, Manilla, Yulgilbar, the Upper Manning, Young, and other districts from which payable chrome has not as yet been obtained, are represented.

5354, from near Manilla, and 1557, from Yulgilbar, show slickensided surfaces.

9037, Coolac, Mooney Mooney Range, shows the junction of the ore with serpentine.

Chromite of good quality has been found near Gundagai, and has been mined more or less actively for some years. Several classes of ores, assaying up to 55 per cent. of chromic oxide, are exhibited.

5200, 4855, Gundagai: slickensided surfaces stained a brilliant green by salts of chromium. **Case 73.**

9539, Quilter's Mine (Gobarralong), showing octahedral faces of crystallised chromite.

5299, Emu Mine: *peridotite*, the rock from which the serpentine appears to have been derived by alteration.

TUNGSTEN.

An alloy of tungsten and iron is used in the preparation of certain varieties of steel, it having been found that the addition of small proportions of tungsten produces a steel of great toughness. It is produced from two minerals only, viz., *scheelite* and *wolfram*.

Tungstate of lime: a white mineral, usually found massive, *Scheelite* characterised by its great density. Specific gravity, 6.*

Scheelite has been found in quantity in the neighbourhood of Hillgrove only, where it occurs as narrow veins traversing granite.

9278: from a 4-inch vein traversing granite.

3972: rich ore containing $57\frac{1}{2}$ per cent. of tungstic acid.

9274, and others: low-grade ores from the Hopetoun Mine, that can be concentrated up to market requirements.

926, Gara Falls, near Hillgrove.

9429 and others: Frogmore, where it also occurs in granite country.

Tuena. Queanbeyan; Hanging Rock.

A green variety of scheelite containing copper.

Cupro-
scheelite

5585, Peelwood. In this ore it is intimately associated with stolzite (lead tungstate) and ordinary scheelite.

* The specific gravity of scheelite is much higher than that of barytes, a mineral sometimes mistaken for it.

Case 73. 7702, Upper Timby, Yeoval: picked portions were found to contain 73 per cent. of tungstic acid, 14 of lime, and 7 of cuprous oxide.

8395, Back Creek.

9344, Orange: assaying 68·35 per cent. of tungstic acid, and 2·56 of metallic copper.

Wolfram.

The most abundant and most valuable ore of tungstic acid. A very heavy black mineral (specific gravity, between 7 and 8), readily cleaving into highly lustrous flakes. It is easily scratched with a knife, yielding a reddish-brown streak.* It occurs as irregular patches in granite, and frequently has a quartz gangue. While principally found in New England, it also occurs in numerous other localities, but never in any quantity.

913, New England: showing excellent cleavage surfaces with good vitreous lustre.

9093, 9544, and 894: crystals of wolfram from the Wild Kate, Torrington, and other claims near Deepwater. Comparison should be made with the titaniferous iron ore, *ilmenite*, from Deepwater, exhibited at the end of this show-case. Wolfram and ilmenite are sometimes very much alike.

9566, 10 miles north-east of Deepwater: coating quartz crystals.

9306, Stony Creek, Rockley.

921 and others, Barrier Range.

7732, near Frogmore, where a small quantity has been mined.

7675, Yalgogrin.

* Wolfram may be readily distinguished from certain other minerals by its physical characters:—

—	Scratched with knife.	Colour of Powder.
Wolfram.....	Easily	Reddish brown.
Hematite	With great difficulty	Blood red.
Tinstone.....	No	Buff.
Tourmaline	No	Almost white.

3757, 3760. Pullitop, near Wagga, where it is associated with **Case 73.** tinstone. (See page 66.) **920**, near Cooma.

918, Eremeran, near Mount Hope: in quartz.

Tungstate of lead. See under **Lead**, case 68.

Stolzite.

TELLURIUM.

This comparatively rare element is found in New South Wales in small quantities only, and invariably in association with bismuth. It has practically no commercial value.

Tetradymite: a soft mineral, closely resembling graphite in appearance. **Telluric Bismuth.**

841 and **2692**, Captain's Flat: with the oxidised material known as *montanite*. A button of tellurium, extracted from the ore, is also exhibited.

9551, Prince of Wales Mine, Gundagai: with gold in quartz. This mineral is not true tetradymite, since it contains a considerable proportion of lead.

7411, Kentucky, Uralla: with gold and quartz.

6925, Hazlegrove, Tarana: with gold and quartz.

6926, Hazlegrove, Tarana: telluric bismuth, oxidised in part, separated from the ore by washing.

5834, Moor Creek, Tamworth: in quartz.

5835, Moor Creek, Tamworth (in **Gold case 50**): shows free gold as well.

10206, Nanima, Bismuth Mine: massive *montanite*, showing occasional specks of tetradymite, from the oxidation of which it must have resulted. The mineral contains a small proportion of manganese.

Tetradymite can sometimes be seen in the quartz from the Nanima Mine.

TITANIUM.

Case 73. A metal frequently found combined with iron in the form of oxides. Of little commercial use, but is said to have been recently, in certain combinations, introduced as a dye for leather.

Ilmenite.

Oxide of iron and oxide of titanium. A black mineral that can be just scratched with a good knife, crushing to a powder that is almost or quite black. *By these characteristics it can always be distinguished from tinstone (see page 66).* It generally occurs scattered through certain igneous rocks, and becomes naturally concentrated into black sand when such rocks are disintegrated. Samples of black sands from different districts are exhibited.

Rutile.

6892, Deepwater : a massive form.

Oxide of titanium.

7854, said to come from Milparinka.

9013, Sydney Flat, Uralla.

8745, Tingha : hair-like crystals enclosed in smoky quartz.

VANADIUM.**Case 73.**

Found only as a staining in various coals and clays.

1143, Leconfield : coal with a green colouration on the parting face, due to the presence of vanadium.

8553, Tomingley Gold Mine : a bright green staining on clay.
(See also under Sydney District, page 184.)

SULPHUR.**Case 73.**

7733, Consols Mine, Broken Hill : free sulphur on galena.

Free sulphur is occasionally found in small grains in iodide quartz.

SELENIUM.

6575, Mount Allen : slate containing a little selenium (not visible to the eye).

Traces of selenium can be found in various sulphide ores.

CERIUM GROUP.

There has, of recent years, been some demand for minerals **Case 73.** containing certain rare elements, more especially *thorium*, which is used in the manufacture of mantles for incandescent lamps.

A resinous, brownish mineral; can be easily scratched with a **Monazite**-knife.

2641, Vegetable Creek: coarse sand.

6725, The Gulf, New England: in parent rock.

6974, Tooloom River: zircon sand containing some monazite.

2115, Tumbarumba: zircon sand containing some monazite.

2639, probably from New South Wales: a large piece.

9276, Dingo Creek, Torrington: in quartz.

9705, Warialda District; associated with carbonate of bismuth.

BOGHEAD MINERAL.

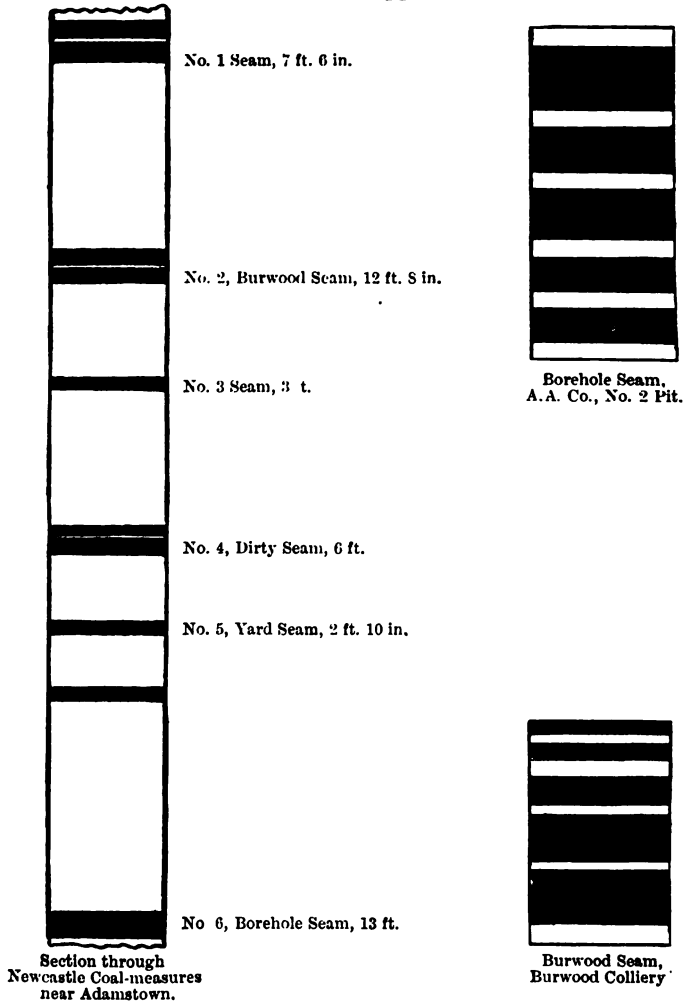
Boghead Mineral, or Kerosene Shale as it is popularly called, **Case 72.** occurs in seams and irregular layers in the coal measures. It contains a much higher percentage of volatile hydrocarbons than true coal. A good shale would yield 150 gallons of crude oil per ton, or 18,000 cubic feet of gas. It is very advantageously mixed with ordinary coal in the manufacture of gas. The principal deposits are those of Joadja, Hartley, and Capertee Valley, but it has been found at many other places. Near the entrance will be found block specimens showing the thickness and general character of the seams at these places. Specimens are exhibited from many localities, but at the time of writing (December, 1901) the collection is in course of arrangement.

Good shale breaks with a characteristic conchoidal fracture. For a good specimen from Hartley, showing this fracture and concentric markings, see **case 138.**

COAL.

The payable coal measures of New South Wales are of Permo-carboniferous age. There are three horizons (see Table of Strata, page 178) of productive coal, separated by non-coalbearing strata, viz. :—

1. Greta series (lowest).
2. East Maitland (Tomago) series (middle).
3. Newcastle series (upper).



The Newcastle Coal Measures are the most important; they attain a great thickness at Lake Macquarie. Of the various seams of coal (see section, page 94) the most important is the Borehole Seam; it is from 8 to 21 feet thick, and is the one worked at the principal collieries. Some of the upper seams have been worked.

Specimens of coal from various collieries, in some cases **Case 74.** accompanied by complete analyses, are exhibited. These include samples from the Borehole, Burwood, Yard and 2-foot seams.

Coal from the Illawarra, Mittagong, Blue Mountain, Dubbo, **Case 75.** Namoi River and Tweed River districts.

A seam of carbonaceous shale occurs at Wilson's Downfall. **Plumbago.** It is of very poor quality.

MISCELLANEOUS MINERALS OF COMMERCIAL VALUE.*

Hydrous sulphate of alumina and potash: a massive mineral **Case 76.** often found in large deposits. It is used as a source of alum. **Alunite.**

Alunite has been largely mined at Bulladelah, in the Stroud District. Specimens are exhibited, ranging in colour from rose-pink to almost chalky-white. Several complete analyses are given.

4216, a rose-red variety cut and polished.

9546, *Halloysite*, hydrous silicate of alumina found associated with the alunite.

Natural alums are of common occurrence, occupying cracks **Alum.** or lining cavities in the Hawkesbury sandstone and other rocks. They do not occur in sufficient quantity to be of commercial value. Zinc has sometimes been detected in them.

3076, Mount Wingen; a hydrous sulphate of alumina with sulphur.

Magnesia alums from Wallerawang, Mount Victoria, Shoalhaven, Capertee, Burragorang.

* For cement, see page 135.

Case 76. Phosphates. Various phosphates and other soluble deposits have been found in the limestone caves at Jenolan; they would be valuable for agricultural purposes if they could be procured in large quantities.

9176, hydrous phosphate of alumina.

9177, hydrous phosphate and sulphate of lime.

7746, hydrous phosphate of alumina with much silica.

9179, hydrous phosphate of alumina and potash (*minerrite*).

9180 and 9715, nitre.

7006, Gordonbrook; a narrow vein of apatite—phosphate of lime—traversing granite.

Fuller's Earth Small deposits at Wingen and Curlewis.

Kaolin. China Clay.—Kogarah, Carlingford, Molong, Mudgee, Cudal, Manning River, Burrowa, Peak Hill, Bombala, Tumut, Parkes, Ulladulla, Kiandra, Dalton, and Dunbible. Several are accompanied by analyses, and a few by manufactured articles.*

Tripolite. Diatomaceous (or Infusorial) Earth: a deposit made up of the siliceous frame-work of microscopic plants known as *diatoms*. The material is very porous and very low in density, owing to the microscopic particles being hollow. A red jasper occurs with the Cooma earth.

Barraba, Cooma, Warrumbungle Mountains, Wyrallah (Tweed River), and elsewhere.

The Cooma deposit has been worked, but only to a slight extent. A little material has also been taken from the Tweed River deposit.

Fire-clay. Maitland, Lithgow, Young, Mount Hope, Waratah, Burruga, Goulburn, Parramatta, with analyses.

Asbestos. Asbestos of good quality has been found in serpentine country at Jones Creek, Gundagai, and a small patch was worked some years ago. Inferior samples are from Rockwell Paddock (Broken

* An ultimate analysis gives very little guidance as to the value of a clay for commercial purposes. The proportion of quartz, felspar, &c., of which clays are generally made up, is much more valuable; an analysis that gives this is known as "*rational*."

Hill), Rockley, Tamworth, Burrows, and Byng. The material from Byng has been used locally to a slight extent for boiler covering.

The largest yet found in New South Wales is from Broken Mica Hill, but is too small to be of commercial value.

In an unnumbered case, immediately to the left of the entrance, will be found a quantity of ochres and other pigments from Dubbo, Larras Lake, Molong, and elsewhere. Several attempts have been made to place these on the market, but with scant success. Kalsomines prepared from local material, and a series of small duplicates of samples recently submitted for valuation in London, with the prices quoted, are exhibited.

Special cases.
Ochres.

For comparison, ochres and umbers from Cyprus, Spain, Ireland, and Cumberland are placed here.

A series of cores from the Wallon Bore, Moree, obtained with the calyx drill from various depths between 350 feet and 1800 feet are shown. The fossils found in the core show that Triassic strata are present beneath the Cretaceous, and it was in the former that Artesian water was struck (at a depth of 2330 feet). Specimens of the porous sandstones which catch and absorb the surface water at their outcrop in Queensland are exhibited below.

Case 77.
Artesian Water.

ORNAMENTAL AND BUILDING STONES.

The Museum possesses a considerable variety of ornamental and building stones from New South Wales. These are displayed on the north wall and in upright show-cases near the entrance.

Immediately to the right of the entrance, on the south wall, are large polished slabs of the following marbles:—

- Cow Flat; white.
- Tamworth; red.
- Marulan; grey.
- Orange; pink.

Of these, the Tamworth and Orange marbles can sometimes be obtained in Sydney. The Tamworth marble consists largely of

the stems of fossil *crinoids* (sea-lilies). Candlesticks and other articles made from it will be found in **case 131** near by. Beneath the larger slabs is a row of smaller ones, containing the following additional varieties:—

Walli; grey with fossil shells (*brachiopoda*).

Bibbenluke; black and white with fossil shells (*brachiopoda*).

Bungonia Caves; dove-grey.

Abercrombie Caves; dirty white.

Yarrangobilly Caves; black.

Mudgee; grey.

Gundagai; cream.

Of these, the Mudgee and Bungonia marbles are very good. The Mudgee marble works as well as the famous Sicilian.

On the same wall is a number of smaller polished slabs from Fernbrook (Bathurst), Mudgee, Molong, Rockley, Rylestone, Cudal, Newbridge, &c. Here is also a table composed of New South Wales marbles.

The visitor cannot fail to be struck with the great beauty of these marbles, and with the variety of colour and pattern obtainable from such localities as Mudgee, Molong, and Fernbrook. For comparison with these, a set of the European marbles best known in London is placed on the south wall; they are described under their trade names.

In **case 133** is a small pyramid of Kempsey marble, and a larger one of Rockley black marble; the latter consists largely of the stems of *crinoids*.

Serpentine.

Serpentine, suitable for outdoor work in general, is exhibited from Bingera and Cowra. A polished slab of Bingera stone will be found on the south wall near the entrance, and a dressed block in **case 135**. In the same case, and in **129**, are various ornaments cut from the stone. The Cowra serpentine is in **case 133**.

Precious serpentine from Byng is shown in **case 124**. It is found in thin layers only, and would be suitable for small work only—if at all.

Green porphyry from Cowra. A good stone, but very expensive **Porphyry**. to work on account of its toughness. **Case 129**.

From the Hawkesbury Series, in **cases 129** and **133**. Large **Sandstone**. dressed cubes from the following quarries near Sydney:—Parramatta, Hunter's Hill, Pyrmont, Randwick, Mosman.

From the Hunter River District (Carboniferous and Permo-Carboniferous Formations). In **cases 133** and **135** are large dressed cubes from quarries at the following places:—Rutherford, East Maitland, Morpeth, Clarence Town, Ravensfield, Muswellbrook, Paterson, Lambton.

Serving as a base to a column of Bingera serpentine in **case 129**, is a cut block of the grey Waratah sandstone—a beautiful stone.

Gabo Island, **case 124**.—A red granite similar to that from Granite. Peterhead (Scotland).

Trial Bay.—A large polished block to the left of the entrance. A pale pink granite, exceptionally easy to polish.

Moruya.—Polished and dressed blocks in **cases 129** and **133**. A grey granite with moonstone felspar.*

Gadara (Tumut District).—A pretty grey granite, taking a good polish and working well. The markings are very uniform.

Bowral.—A grey rock serving equally well in the rough or "**Trachyte**."† polished. **Case 133**.

* May be seen in the columns of the G.P.O., Sydney.

† Properly speaking, this rock is a *syenite*. It may be seen in many Sydney buildings, notably that of the New York Equitable Life Assurance Company, George-street.

MINERALS OF ECONOMIC VALUE, LOCALITIES OTHER THAN NEW SOUTH WALES.

These show-cases should be studied from left to right.

GEMSTONES.*

Case 78 Diamond.

South Africa.—In the first column on the left are diamonds and models, the largest of the latter representing a stone weighing $103\frac{1}{2}$ carats.

5962, a stone weighing $1\frac{1}{4}$ carats, represents one of the most characteristic forms assumed by diamonds crystals—an eight-sided double pyramid (*octahedron*).

2343, a not uncommon flattened form of *tetrahedron* (3 carats) —

5961, a very remarkable specimen ($3\frac{1}{3}$ carats), consisting of three cubes intergrown. It is rare to find the diamond crystallising in the form of the *cube*. The edges of the *cube* are modified by a series of overlapping faces of the *octahedron*, giving rise to an appearance of bevelling such as would result from the presence of the *rhombic dodecahedron*. The stone is grey in tint, measuring 5 mm. in length of edge, and weighing $3\frac{1}{3}$ carats.

2345, *carbonado*.

2346, a most interesting specimen, showing a small crystal embedded in the so-called “blue ground” in which the Kimberley stones are found. The crystal has the usual pyramid shape: the striations on the faces should be noticed.†

The nature of the country, and of the material in which the diamonds are found, is well shown by a good series of specimens, and by descriptive labels and diagrams at the head of the show-case. The stones are found scattered through a decomposed material occupying oval pipes vertically traversing the basalts, shales, and quartzites of the country. This material is known as “blue ground.”

* As the diamond-bearing material is now crushed immediately on coming from the mine, it is very unlikely that specimens such as this will be forthcoming in the future.

† For remarks about diamonds, and notes on New South Wales gemstones, see page 15.

Several pieces of blue ground, showing cavities from which large diamonds have been taken are exhibited. Near the surface the blue ground passes into a red soil.

There is no doubt that these pipes have been drilled through the Earth's Crust by an explosive force acting from within, and they may, therefore, be reasonably expected to continue to a depth greater than that at which mining would become possible. The blue ground is a breccia composed of a heterogeneous mixture of irregular fragments of various rocks which have been projected upwards from unknown depths. The diamonds have not been formed where they are now found, but have accompanied the other material in its upward journey. The breccia cannot, therefore, be regarded as the true home of the diamond; but important evidence, obtained very recently, points to an igneous rock consisting largely of olivine, garnet, and augite as the original source (see page 16).

Some of the minerals associated with the diamonds in the blue ground, *e.g.*, bronzite, mica, garnet, calcite, pyrite, gypsum, and natrolite, are exhibited.

West Australia.—A diamond-bearing cement from Nullagine.

Specimens of *spinel*, *topaz*, *emerald*, *lapis lazuli*, *garnet*, *zircon*, *Gemstones*, *turquoise*, and *crocidolite* will be found here, but call for little comment.

For *beryl*, see page 154.

2104, Gippsland (Victoria), 9085, Wanganilla (Queensland), *Turquoise*, and 8525, Arizona, show the mineral as it generally occurs in veins traversing slate.

This beautiful and well-known substance from South Africa *Crocidolite*, is an asbestos-like mineral that has been saturated with silica and practically converted into quartz, while still retaining its original structure.

Specimens from Queensland, Mexico, and Hungary. The *Opal*. Queensland opal generally occurs in veins and masses in iron-stone. On the wall near the show-case are pictures of the Queensland opal-field.

Case 77.**PLATINUM.*****Native
Platinum.**

The principal platinum mining field is that in the Ural Mountains (Russia). Here, as everywhere else, the platinum occurs in alluvial wash, small specimens of which from the Demidoff Estate are exhibited. 2280, alluvial wash. 2281, concentrates from first washing. 2282, concentrates from second washing. 5691-2, crude platinum.

The largest nugget yet found is in the collection of Prince Demidoff. A cast of it is exhibited here.

Sperrylite.

In the nickel mines at Sudbury in Canada, and at one other locality, has been found the only natural combination of platinum with another element known to exist. This is the mineral *sperrylite*, in which platinum is combined with arsenic, forming tin-white crystals. Sperrylite is found in small quantities only in an ochreous matrix. Specimens of both are exhibited.

Case 77.**MERCURY.****Cinnabar.**

The collection of cinnabar ores here is very good; Spain, California, and Russia, together with various Australasian localities, being well represented.

Spain.—3215, from the well-known locality of Almaden, is the only good specimen of crystallised cinnabar in the Museum. 6002 shows native quicksilver in minute globules on the cinnabar.

California.—8409 shows cinnabar crystals; 8410 native mercury in abundance. 3861 appeals to the imagination, coming as it does from the city of San Francisco, which town is said to be built over a deposit of cinnabar.

New Caledonia.—Although no mining for mercury is as yet carried on in the island, cinnabar has been found in several localities—among others Nakety. Varieties of schist, ironstone, and other rocks containing cinnabar, are exhibited. 7811, believed to come from New Caledonia, shows cinnabar seated on galena.

New Zealand, Queensland, Victoria, Russia, British Columbia.

* For remarks about platinum, and notes on New South Wales specimens, see page 21.

GOLD.

Case 80.

Quartz from Mount Morgan, Ravenswood, Eidsvold, Gympie, Queensland, Rockhampton, Charters Towers, Mount Shamrock, Croydon, and elsewhere, mostly representing these fields as they were some years ago.

292, Mount Morgan ; ironstone gossan, with characteristic iridescent tarnish. A large specimen of the gossan is shown in case 103.

6423, Mount Morgan ; ironstone rich in gold.

1185, Mount Morgan ; auriferous sinter.

2873, Near Rockhampton ; gold coating crystals of pyrites.

2680, Gympie ; calcite crystals showing gold.

7016, Waratah Mine, Croydon ; quartz showing native silver, and assaying about 11 oz. gold and 400 oz. silver per ton.

2656, Mount Bartle Frere ; alluvial gold.

In case 116 will be found igneous rocks from the Croydon Gold-field, and country rocks from Gympie.

A few quartz specimens from Sandhurst and elsewhere. Victoria.

6753, Golden Mountain, Goulburn River ; granite showing gold.

7243, Glynn ; auriferous quartzite. Tasmania.

A few gold ores from South Australia and New Zealand.

Kalgoorlie.—Among the most interesting of the specimens in the Museum is the collection of telluride ores from Kalgoorlie. Case 79.
The ore occurs in a highly altered igneous rock, probably to some extent granitic in origin. It is characteristically dark green in colour, with a tendency to a schistose or slaty structure near the ore-body. The ore-body itself is not a lode, but a zone of country-rock, highly mineralised and more highly altered than that surrounding it. The telluride minerals occur in veins and blotches. Several varieties, but principally the pale brassy *calaverite*, are present. Picked specimens of these tellurides will be found in case 92 ; here only the ordinary

West
Australia.

ores, in which tellurides are generally not visible to the eye, are exhibited. In case 128 will be found a fine specimen showing a vein of gold tellurides traversing the rock.*

In the oxidized ore from near the surface will be noticed a peculiar clay-like form of gold—the so-called “mustard” variety. This appears to be characteristic of the weathering of telluride ores. The tellurium, being very volatile, passes off, leaving the gold in this mustard-like condition. Mustard gold is also found at Cripple Creek, Colorado (see 8624 in case 92). 8438, 8426, 9330, and other specimens in the first two rows show this well. 8455 shows a chocolate tint, also rather characteristic of the weathering of tellurides. The metallic mineral showing in this specimen is *pyrite*, not telluride of gold. A series of ores from various mines is exhibited, in which the metallic mineral showing is generally *pyrite*.

8509, Kalgurli Mine; a light-coloured ore with specks of titaniferous iron scattered through it. Titaniferous iron appears to occur in most of the ore and country rock.

8513, Great Boulder Mine, has been cut to show the brecciated character of the ore.

8470, Block 45; *calcite* with *calaverite*, one of the rare instances in which gangue minerals accompany the Kalgoorlie ore.

Auriferous quartz from Mallina, Mount Ida, Coolgardie, Marble Bar, Yalgoo, Pilbarra, Menzies, the Murchison, and other localities.

1432, Lake Austin; gold with *gypsum*.

8796, 8476, Coolgardie; gold with *hornblende*.

1430, Lake Austin; gold on *lydian stone*.

9562, Donnybrook; filamentous gold in pulverulent material.

Kanowna Lead.—Rich gold was found here beneath a false bottom of the travertine which is found covering large areas in

* The mode of occurrence at Kalgoorlie is very different from that at Cripple Creek, Colorado (see page 106). It should be borne in mind that there is, at present, no reason for believing that any particular kind of rock is more favourable to the occurrence of tellurides than another, and prospectors should rather aim at identifying the *minerals themselves*.

the West. Specimens of rich wash-dirt, travertine false-bottom, bed-rock showing gold, pug, and associated minerals are exhibited.

A few specimens from New Guinea, Borneo, and New Caledonia. **Case 79.**
East Indies,
&c.

10028, Celebes; a quartz geode (occurring in limestone), with platy gold on the quartz.

10027, Celebes; veins of auriferous quartz in porphyry.

10026, Sumatra.

A typical series of auriferous quartz from the working mines of United States. California. Also ores from Oregon, Dakota, Washington, Virginia, Mercur, and elsewhere.

The telluride ores of Cripple Creek, Colorado, will be of interest:—

9189; a volcanic rock, andesite, showing a joint-face coated with *fluor* and *sylvanite* (telluride of gold and silver).

9191; a very common brecciated form.

6467; with purple *fluor*. The presence of fluor is regarded as an indication of gold.

***8618**; $\frac{1}{2}$ -oz. ore, containing purple *fluor* and *antimonite*. Various other ores with assay values up to 50 oz. per ton are shown.

***8624**; oxidized ore, showing the peculiar clay-like variety of gold (see page 104) which appears to be characteristic of the oxidation of telluride ores.

***8619, 8628**, are of exceptional interest. Each specimen shows crystals of telluride of gold from which the tellurium has partly been removed, probably by volatilization, the gold remaining as a pseudomorph.

9190; average rich ore; 4-oz. stone.

In **case 92** (see page 125) will be found picked specimens of gold-telluride minerals from Colorado.

* These specimens are in case 92.

- Europe.** Quartz from North Wales and Russia.
- South Africa.** A large block of the famous blanket will be found on a table near the door.
- Gold quartz from Mysore will be found in **case 103**, and from Ontario in **104**.

Case 81.**SILVER.**

The earlier portion of this case contains a number of silver minerals from various parts of the world, arranged according to composition.

- Native silver.** **411**, Zacatecas, Mexico ; wiry form occupying cavities.
- 3498**, Chihuahua, Mexico ; in *calcite*.
- 432**, Freiberg, Saxony ; a beautiful arborescent form.
- 8633**, Bull Hill, Colorado ; in *stephanite*. In this specimen the native silver is growing out of the stephanite, from the alteration of which it has resulted.
- 405**, Mexico ; a fine specimen of wire silver on *galena*.
- Others from Queensland (Croydon), Russia, Tasmania, and Freiberg.
- Electrum.** Silver-gold alloy. **6800**, Russia.
- Horn silver.** Silver chloride ; a very soft waxy mineral, blackening on exposure.
- 409**, Zacatecas, Mexico. **3551**, Idaho ; on kaolin. The dull grey crust of the horn-silver can be clearly seen against the white background.
- Other specimens from Queensland, Idaho, and Chili.
- Bromyrite.** Silver bromide. **381**, from Chili.
- Argentite.** Silver sulphide ; a very soft, black mineral, easily cut with a knife-blade, leaving a shining surface.
- 8149**, Comstock Lode, Nevada ; little black masses in quartz.
- 380**, Chili ; massive *argentite*.
- 8664**, Himmelsfürst Mine, Freiberg, Saxony.

Sulphide of silver and iron. **3569**, Owyhee County, Idaho; **Sternbergite**. with copper pyrites in white quartz.

Silver antimonide (see page 46). Specimens from the Hartz Dycrasite. and from Cornwall.

Sulph-antimonide of silver (see page 46). **8633**, Bull Hill, **Stephanite**. Colorado; massive variety.

431, Freiberg, Saxony; crystals on quartz.

Sulph-antimonide of silver. **410-412**, Zacatecas, Mexico; **Pyrargyrite**. quartz richly coloured with pyrargyrite. **377**, Chili; massive variety, with copper-pyrites and quartz.

8148, Cottonwood, Utah; in quartz.

426-428, Andreasberg, the Hartz.

Arsenic silver.

Sulph-arsenide of silver. **413**, Zacatecas, Mexico; in quartz. **Proustite**. **384, 385**, Chili; massive.

Sulphide of silver, copper, antimony, and arsenic; a black **Polybasite**. mineral, containing about 70 per cent. of metallic silver, and, therefore, a valuable ore. **383**, Mexico.

Sulph-antimonide of silver. **433, 434**, Hiedelencia, Spain; **Freieslebenite** good crystals.

Bismuth-silver. **441**, Schapbach.

Schapbachite.

A number of typical galena and other ores of silver from **Silver ores**. Colorado, Arizona, Missouri, Idaho, Utah, Washington, and **United States**. other American localities.

3869, Leeds, Utah; a silver-bearing sandstone, with plant remains. In geological age, and, to some extent, in general appearance, this resembles the Hawkesbury sandstone of the Sydney District.

2040, Great Comstock Lode, Nevada; quartz from the great depth of 3,250 feet.*

Galena ores from Great Britain.

Europe.

A series of ores from the Silver Spur Mine, Texas.

Queensland.

* The workings on the Comstock Lode were carried to such a depth that the internal heat of the Earth's Crust became almost unendurable.

Case 82. Argentiferous galena, principally from Ravensfield and Townsville.

Tasmania. Argentiferous galena from Zeehan and Dundas.

South Australia. Ores from the Northern Territory.

New Zealand.
West Australia.
Victoria. } A few silver ores.

Mexico. Silver ores from the Zacatecas Mines.

Case 82.

LEAD.

Selected crystallised specimens of lead minerals are arranged here. Numerous samples of galena and other ores of lead will be found under **gold** and **silver**.

Cerussite. Lead carbonate **5819, 9333**, Dundas, Tasmania; the snow-white crystals show up extremely well against the dark background; they are not unlike some of the Broken Hill specimens in **case 62**. Others from Arizona, New Caledonia, Weardale (Eng.), and Russia.

Anglesite. Lead sulphate; **373**, crystals from the Eveleen Mine, Northern Territory; **23**, fine crystals from Pilau, New Caledonia; **10007**, Tasmania; large crystals.

Linarite. Copper-bearing, lead sulphate,; **3375**, Ygnacio Mine, Cerro Gordo, California.

Wulfenite. Lead molybdate; **3371, 7438**, Arizona; beautiful, large platy crystals of a rich, red colour.

3213, 3482, Organ Mountain, New Mexico; sulphur-yellow platy crystals on calcite. Some of the specimens procured from there are very fine.

Crocoisite. Chromate of lead. Superb specimens from Dundas, Tasmania, are exhibited in **case 90** (see page 122).

Pyromorphite. Phosphate and chloride of lead, **9332**, Sylvestre Mine, Zeehan; small, dark green, velvety crystals. Idaho, Missouri, Cumberland (Eng.).

Some of the lead-bearing minerals are among the most beautiful in Nature. Of these may be mentioned *crocoisite*, *wulfenite*, *pyromorphite*, and *cerussite*; they are all very fragile.

Arsenate and chloride of lead; **886**, (var. *campylite*). Europe. **Mimetite**.

Lead sulphide, **3500**, **7447**; large cubes from Joplin, Missouri. **Galena**. Joplin is a famous American zinc and lead mining district; fine crystals of zinc blende are also found in the mines (see case **87**). Lead-zinc ores from Wisconsin will be found in case **104**.

1800, Weardale Lead Mines, England; cubic crystals, showing faces of the *octahedron* well, associated with fluor and chalybite.

8506, Wheal Fortune Mine, Northampton, West Australia; cubic crystals, showing faces of the *octahedron*.

848, Alston, England; somewhat similar to the Wheal Fortune specimen.

1301, Weardale, England; crystallised with calcite.

6252, Nanty Garn, Wales; octahedral crystals.

457, Carmarthenshire, Wales; showing cubical cleavage and octahedral faces, associated with the dog-tooth variety of calcite.

469, Derbyshire, England; with fluor.

7989, Rutland Cavern, Matlock, Bath, England; a lead mine worked by the Romans. The specimen has been taken from the old workings.

COPPER.

Cases 84,
103,
(in part).

The Copper-Field of the Lake Superior District is one of the most important in the world, and is of exceptional interest from the very peculiar nature of the deposit, and from the depth to which mining operations have been carried—over a mile. The **Lake Superior** ore consists principally of native copper, and occurs, not in lodes or veins, but scattered through conglomerates and melaphyres of early Palæozoic Age. The formation consists of a succession of lava flows and of sedimentary conglomerates and sandstones, native copper having been deposited in the cavities of the

vesicular lavas,* and between the pebbles of the conglomerates. Occasionally boulders of copper have resulted from the complete replacement of portions of the rock. It seems most probable that the copper has been derived from some of the mineral constituents of the igneous rocks. The exhibit from this field is very complete, and well exemplifies the mode of arrangement followed in the Museum. The series commences with a few picked specimens of native copper, followed by the crushing ores, samples of coarse screenings and concentrates in different degrees of fineness, the country-rocks in different positions and mines, and associated minerals.

At the head of the case will be found descriptive labels, maps, and plans.

In this case (84) may be noticed—7439, crystallised *native copper*, and 5205, *native copper* welded to *native silver*.

2059, a quartz-porphry pebble from one of the conglomerate beds, which are sometimes largely made up of igneous material.

2060, the contact of melaphyre with conglomerate. The amygdaloidal character of the melaphyre will be noticed.

Larger specimens will be found in upright case 103, which show the structure of the country well, viz. :—

3402, conglomerate with large pebbles of porphyry showing native copper and junction with melaphyre.

3412; somewhat similar to the above.

3407, Tamarack Mine; a good specimen of copper-bearing conglomerate with pebbles of porphyry.

3398, Tamarack Mine; a large pebble almost entirely replaced by native copper.

This replacement of a porphyry pebble by native copper is a telling instance of the powerful action of mineralising solutions under the conditions prevailing in the Earth's Crust.

Arizona.

On this, the third in importance of the American copper fields, the ores are in the main oxidised. A special feature is the beautiful crystals of *azurite* (blue carbonate of copper)

* For similar occurrences in Australia, see page 65.

that have been found, moderately good specimens of which are exhibited.

3441, *melaconite*—black oxide of copper. 632, *cuprite*. 3194, *cuprite* crystallised with *native copper*.

3193, Copper Queen Mine, Bisbee; *cuprite* crystals showing faces of the *cube* and *octahedron*

7436, Bisbee; *cuprite*—a very pretty specimen. 3203, Morenci; *azurite*. 3195, Morenci; *azurite* in groups of aggregated crystals. These nodules occur sparingly through immense beds of kaolin, and are not worth working.

640, *chrysocolla*. 3192, *copper sulphate*. 3580, *bornite* with *malachite* and quartz, assaying $1\frac{1}{2}$ oz. of gold and 9 oz. of silver per ton, and 31 per cent. of copper.

In case 105, *malachite*.

This is the greatest mining camp in the world, and has the **Montana**. largest output of copper. The ores are low-grade sulphides. Rich specimens of glance and bornite are exhibited.

3202, Amherst County, Virginia; *bornite*.

Other North
American
localities.

667, French Creek Mine, Pennsylvania; crystallised *copper pyrites*. This is the only specimen in the Museum showing crystals of copper pyrites. The mineral is generally found massive.

Sulphide ores from California.

3590, Ormay County, Colorado; *fahlore* with *cosalite* (argentiferous sulphide of lead and bismuth).*

622, Eagle Bay, Canada; *native copper* with *calcite*.

Sulphide ores from Harvey Hill, Canada.

652, El Bolo Mine, Baja, Mexico; *malachite* with *gypsum*.

South
America.

A few ores from Chili are shown. The copper industry of this country was once very considerable, but is rapidly waning. *Atacamite*, the oxy-chloride of copper, constituted a good proportion of the ore. A good specimen (641) is exhibited.

* This rare mineral has also been found in New South Wales. (See page 87.)

Europe.

639, Russia; *chrysocolla*, showing well the encrusting habit of the mineral.

6799, Russia; *malachite*. Russian malachite has a great reputation, being in request for ornamental purposes.

646, Laurium, Greece; *azurite* with *adamite* (arsenate of zinc). Various ores from Scandinavia, Russia, Spain, Saxony, and Italy are exhibited.

Cornwall.

The copper industry of Cornwall is almost extinct. Crystallised specimens, and rare copper minerals were frequently found in the Cornish mines.

6230, South Condurrow Mine; *native copper*. **635**, Redruth; *cuprite* in beautiful octahedral crystals. **634**; *cuprite* in octahedral crystals. **6247**, Botallack Mine; a variety of *atacamite* known as *tallingite*—a blue encrustation. **658**, Redruth; crystallised *bornite*—bornite is generally massive. **7446**, Bristol (U.S.A.); crystallised *copper glance*.

Less common
Copper
Minerals.

Chalcotrichite, a hair-like variety of *cuprite*. **638**, Cornwall; beautiful silky crystals bridging across cavities lined with *cuprite*. **3207**, Arizona.

Boléite, oxy-chloride of copper and lead, with chloride of silver. An ultramarine-coloured mineral crystallising in perfect cubes. It has been found at Broken Hill. **5405**, Mexico.

Linarite, hydrous sulphate of copper and lead. **5811**, Cerro Gordo, California.

Libethenite, hydrous phosphate of copper; of a rich green colour. **6246**, Phœnix Mine, Cornwall.

Chalcosiderite, hydrous phosphate of copper and iron. **6235** Phœnix Mine, Cornwall; a green encrusting substance.

Olivenite, hydrous arsenate of copper; a yellowish green fibrous mineral. **8403**, Tintic, Utah, U.S.A. **6244**, **673**, Cornwall.

Conichalcite, arsenate of copper and lime. **8018** (argenti-ferous), Tintic, Utah, U.S.A.

Phosphorochalcite, phosphate of copper. 672, Rheitenbach, the Rhine.

Tennantite, arsenical fahlore. 6258, St. Just, Cornwall. 10362, Mount Lyell, Tasmania.

Bournonite, sulphide of antimony, lead, and copper. 671, Herodsfoot Mine, Cornwall, shows the characteristic cog-wheel-like crystals moderately well. 3621, Black Horse, Idaho.

Enargite, sulph-arsenate of copper. 10018, Mexico.

Various ores from Moonteroo, Northern Territory, Burra **Case 83.**
Burra, Kapunda, Moonta, Walleroo, and Balhannah. South
Australia.

5689, Burra Burra, *azurite* with *malachite*; cut and polished.

1247, Walleroo, and other specimens of crystallised *atacamite*.

Various ores from Rockhampton, Cloncurry, Clermont, Queensland.
Charters Towers, Peak Downs, Kilkivan, Mount Flora, Star
River, Gladstone, and Chillago.

5792, Dottswood Mine, shows *native copper* on porphyrite.

9011, the copper plant, which is believed to mark the outcrop
of copper lodes.

In **case 105** is a beautiful specimen of polished malachite from
Peak Downs.

9733, Chillagoe; *chrysocolla* pseudomorphous after *azurite*.

Mount Lyell sulphides. 7249, Globe Mine, Mount Agnew; Tasmania.
fahlore with dolomite.

Native copper and carbonates in volcanic rock from the Nelson **New Zealand.**
Mine.

Native copper, *cuprite*, *malachite*, *azurite*, and *copper pyrites* **New Caledonia.**
from various localities.

Copper pyrites and *bornite* from Namaqualand. South Africa.

TIN.

Case 85.

Numerous lode tin ores from Herberton, and some from **Queensland.**
Stanthorpe; 495, Stanthorpe, shows good crystal faces.

501 and 1704, Cannibal Creek, Cooktown; massive ores closely
resembling those from the Barrier Range of New South Wales.

Among the numerous specimens exhibited, the following may be noted:—

Tasmania.

6743, Roy's Hill; associated with tourmaline.

7617, Mount Housatop; stream tin containing minerals of the rare earths.

5958, Rix Hill, Ben Lomond: with blende.

5948, Commonwealth Mine, North Dundas; with magnetic pyrites.

Mount Bischoff is well represented. 5938 and others illustrate the topaz rock, so characteristic of this mine. (See page 171.)

**South
Australia.**

Tin-bearing pegmatite and other ores from Port Darwin and the Northern Territory.

**West
Australia.
Penang.**

Varieties of stream tin from Greenbushes. The Greenbush ore contains minerals of the rare earths.

Varieties of stream tin.

United States.

Stream tin from South Dakota and Wyoming. Among the lode specimens those from Dakota should be specially noted for their resemblance to the Barrier Range ores; 3229, for instance, a pegmatite with much light-coloured mica and dull-looking massive tinstone could not be distinguished from an ore like 7970 from Poolamacca (case 64.)

Cornwall.

Numerous ores from different mines and levels.

555, and others, show good crystals. 6216, St. Agnes; wood tin; polished specimen.

Saxony.

The Erzgebirge Mines are represented by the following:—

8707, 8710; tinstone associated with molybdenite.

8648; tinstone in topaz rock.

8647; tinstone in topaz rock. In this specimen the topaz has undergone alteration into a hydrous mineral—*gilbertite*.

8686; granite impregnated with tinstone—the “zwitter” structure of the Germans.

In **case 128** will be found a block of granite traversed by veins of tinstone and other most instructive specimens from the largest tin lodes, from Zwitterstock, Altenberg.

Stannite, tin-pyrites, from Cornwall and Tasmania, will be found at the end of the case.

IRON.

Case 86.

Massive ores from Canada, Russia, Scandinavia, Saxony, Elba, **Magnetite**, **Pyrite**, and the United States.

3599, Kittitas County, Washington; a specially valuable iron ore; it contains no refractory elements, and a considerable quantity of fuel and fluxing material.

588, **6040**, French Creek Mine, Pennsylvania; crystallised **Pyrite**.

586, Hull, Canada, and **9288**, Essex County, New York State; **Octahedral** crystals, showing faces of the *rhombic dodecahedron*.

3774, Chillagoe, North Queensland; a large twinned *rhombic dodecahedral* crystal of magnetite, with edges about $1\frac{1}{2}$ in. long.

8773, Chillagoe, in **case 126**; a cluster of *rhombic dodecahedral* crystals.

581, Digby, Canada.

Martite.

8524, Thomas Mountain, Utah; large *octahedral* crystals.

3333, Michigan; a good specimen of the variety of hematite **Hematite** known as *kidney ore*, from its appearance.

Ores from Canada and various localities in the United States.

The collection of ores from the Lake Superior mines is very complete, representing the deposits and classes of ore worked. The deposits are of enormous size, and the ore is of prime quality. The cost of mining is very small, steam-shovels being used, as the ore is generally soft. The cost of freight to the iron-works is, however, considerable, the distance traversed being about eight hundred miles, and necessitating several transfers of

the ore from rail to water, or the converse. Ores are exhibited from the Marquette, Mesaba, Gogebec, Vermillion, and Menominee Ranges. The ore from the first-named locality is largely micaceous-iron schist and specular ore; from the others it is mainly ochreous.

Partial analyses accompany some of the exhibits.

Case 88. Several very fine specimens of the famous Cumberland (Eng.) hematite; 569, 571, 573, and others; *kidney ore*. 4188; ochreous. 574, 575, 576; *specular iron ore* with crystallised quartz. These are fine attractive specimens.

Saxony, Westphalia, Belgium, Russia, Gippsland (Vic.), Ravenswood (Q.), and Kapunda (S.A.).

583 is an average sample of the Spanish ore shipped in large quantities to the English ironworks.

5942, Blythe River, Tasmania; a good ore, containing 95.2 per cent. of ferric oxide, 4.8 per cent. of silica, and but little of phosphorus.

Turgite. Hydrated red oxide of iron. 584, Radintz, Bohemia.

Gothite. A variety of hydrated oxide of iron.

594, Restormel Mine, Cornwall.

Limonite. Stalactitic and fibrous forms from Canada and the United States 3436, and others; limonite ores from the Longdale Mine Virginia, with a sample of the limestone flux in use there.

6187, North of Ireland; aluminous iron ore used for fluxing.

Chalybite. 8489, Hannan's Lake, West Australia: limonite pseudomorphous after chalybite.

Numerous other specimens are exhibited.

6933-4; the Cleveland ore (North Yorkshire) from which so much of the English iron is obtained. The ore is an impure carbonate.

7244, Mount Black, Tasmania; showing excellent little crystals of chalybite.

5113, Melbourne; a spheroidal form of carbonate of iron, known as *sphæro-siderite*, occupying spherical cavities in basalt.

5186, Coolgardie.

Iron silicate.

Hydrous silicate of iron and alumina; **9868**, Chamoison, *Chamoisite*.
rance. Copiapite.

Hydrous sulphate of iron; **7443**, Chili.

Hydrous phosphate of iron; **4196**, Victoria; beautiful crystals radiating groups; **3864**, Utah; gold- and silver bearing.

Hydrous phosphate of iron; **6210**, Cornwall; **3453**, Virginia. *Dufrenite*.

Fluo-phosphate of iron and manganese; **8675**, Saxony. *Triplite*.

Di-sulphide of iron; **6193**, Cornwall; good *cubic* crystals. *Pyrite*.

601, French Creek, Pennsylvania; good *octahedral* crystals.

8143, Cornwall; *mammillated* form.

Di-sulphide of iron, crystallising in *rhombic* forms; very
ble to decompose. *Marcasite*.

608, **6192**, **6194**; nodules from the Chalk Formation of England.

94 shows the rhombic platy crystals well; it will be noticed
w very different they are from the common cubes of pyrite.

604, Belgium; a nodule; **6190**, Alston (Eng.); decomposing.

3499, Joplin, Missouri; where it is of very common occurrence
the zinc-lead mines.

Magnetic pyrites, sulphide of iron; Bavaria and Tasmania. *Pyrrhotite*.

See "Arsenic."

Mispickel.

Titaniferous iron ore, ilmenite. Massive forms from Canada
d Norway; sands from Canada and New Zealand. *Ilmenite*.

8195, beach sand, Onehunga, New Zealand; containing
 $\frac{1}{2}$ per cent. of metallic iron and 13 per cent. of titanac acid.
ie presence of titanac acid in quantity in an iron ore renders it
ry refractory and difficult to smelt. Up to the present all
tempts to utilise these sands commercially have failed.

600 and **6815**, Russia; good crystals in *pegmatite*.

6215, Iser, Bohemia; a granular variety known as *Iserine*.

Case 87.

ZINC.

- Zincite.** Oxide; a pretty red mineral found in quantity at Franklin, New Jersey. 461, with franklinite.
- Franklinite.** Oxides of zinc, iron and manganese; a black mineral found only at Franklin, New Jersey, where it occurs in sufficient quantity to constitute a valuable ore. The crystalline form is very characteristic, and is well shown by the specimens exhibited: the faces commonly seen are the *cube* and *octahedron*.
- Calamine.** Carbonate of zinc.* A variety of encrusting forms, of different colours, from Spain, Greece, Wisconsin Virginia, the Northern Territory of South Australia, Mexico, &c.
- Goslarite.** Hydrous sulphate of zinc; a magnesia-bearing variety, found in old mine workings at Callington, South Australia.
- Willemite.** Anhydrous silicate of zinc. 468, Franklin, New Jersey.
- Smithsonite.** *Hemimorphite*, hydrous silicate of zinc; Missouri, Russia.
- Blende.** Sulphide of zinc. 7544, Asturias, Spain; transparent amber-like variety. Weardale (England), Cumberland, Cornwall, Derbyshire. The Weardale specimens consist of small, lustrous, black crystals, seated on or associated with fluor, chalybite, calcite.

937, Przibram, Bohemia; variety containing cadmium.†

Granular ores from Spain, Scandinavia, Russia.

3562, Kansas; light-coloured crystalline variety.

3459, Clear Creek County, Colorado, shows good crystal faces.

Joplin, Missouri, is a noted locality for blende. It is represented here by 7449, beautiful resinous crystals; 3496, globular form in dolomite; 3497, Chewkite, Missouri; beautiful little-ruby crystals.

* Much confusion prevails in the nomenclature of some of the zinc minerals. For instance, the carbonate of zinc, here termed *calamine*, is often called *smithsonite*, and *calamine* is applied to the hydrous zinc silicate. Here, as throughout this handbook, preference is given to British usage.

† Cadmium is not infrequently present in blende; if in quantity, it may depreciate the mineral as an ore of zinc. Its presence can only be determined by chemical methods.

ANTIMONY.**Case 87.**

Specimens are exhibited from California, Queensland, and **Native Antimony.**
 orneo. That from Queensland—Port Mackay—shows good
 ystals.

Earthy oxides of antimony; Mexico, Spain, Borneo, Victoria. **Cervantite, &c.**

Oxide of antimony; Canada, Victoria. The Canadian **Valentinite.**
 ecimens are associated with kermesite, and closely resemble
 at from New South Wales in **case 68.**

An oxide of antimony; **3878**, California.

Partzite.

Sulphide of antimony; California (crystallised), Canada, **Antimonite.**
 rneo, Portugal, Corsica, Spain (showing the ore in different
 ges of dressing), Hungary, New Zealand, Queensland, New
 ledonia.

Sulph-antimonide of lead; **6257**, Sweden.

Boulangerite.

COBALT.**Case 89.**

New Caledonia (3-6% of cobalt); Victoria, Cornwall, Queens- **Cobaltiferous**
 d. **wad (asbolan).**

Hydrous arsenate of cobalt. South Australia.

Erythrine.

3635, Schneeberg, the Erzgebirg, Saxony; a crystallised
 ecimen; kept covered, as the colour is said to be destroyed on
 osure to light.

Arsenide of cobalt; Schneeberg, Saxony.

Smaltite.

Sulph-arsenide of cobalt; small crystals from Sweden. The **Cobaltite.**
 rystal form (the *pentagonal dodecahedron*) is very characteristic;
 is well shown by the model exhibited.

Sulphide of cobalt with nickel, iron, &c.; **10019**, Mexico.

Linnaeite.

NICKEL.**Case 89.**

Nickel is chiefly used in the preparation of alloys with copper,
 ch as nickel-silver, and of nickel steel. A great variety of
 inerals in which nickel is an essential constituent are known,
 at these do not often occur in sufficient quantities to be used

as cres. The nickel of commerce is derived almost entirely from rocks and minerals, in which it occurs in varying quantities as an accidental constituent.

new
ledonia.

The ore consists of bands and veins of serpentine containing varying proportions of nickel. The metal occurs in the form of a silicate of nickel and magnesia, forming a mineral known as *noumeaite*. Two varieties are known, a green and a brown; the miners, moreover, apply a number of local names, such as "rose nickel," "magnesia nickel," that have no definite meaning. It would appear as if the nickel were concentrated in the serpentine by a process of natural secretion, and it is probable that the deposits are practically confined to the weathered portions of the rock. The nickel is concentrated in the cracks and outer shells of serpentine boulders. These outer shells are more rotten than the harder kernels, and can be readily separated. A large block of the ore is contained in the end compartment of case 67.

3426, 553; beautiful specimens of grape nickel—so called from the general appearance of the ore.

8873; tabular crystallised form of *noumeaite*.

8870, 8858, 8864; varieties of the serpentine country-rock, locally supposed to be favourable or unfavourable to the occurrence of nickel, as the case may be.

8850; a serpentine boulder, in the outer portion of which the nickel ore is concentrating.

8869, 8845, 8860; red soil and pisolitic ironstone overlying the deposits.

3218, 3892; *Noumeaite* from Oregon.

Emerald Nickel, hydrous carbonate; 6956 and 561, Tasmania —

Millerite, sulphide of nickel; Tasmania.

Pentlandite, sulphide of iron and nickel; 4071, Tasmania.

Kupfernickel, arsenide of nickel; 562, 564, and 10360, Norway, Hesse, and Tasmania, respectively.

Nickeliferous Pyrrhotite; 5944, Tasmania. 3535, Ontario.

Arsenate of Nickel; 3891, Nevada.

regon
asmania,
urope, and
her
calities.

Ullmanite, sulph-antimonide of nickel ; 563, South Australia.

Awaruite, a peculiar alloy of iron and nickel found in the iron-sands of the New Zealand beaches. (3063).

At the important nickel-producing district of Sudbury, Ontario, Canada, Ontario. the ore is of a very different character to that from New Caledonia. Here it consists of *magnetic pyrites* (*pyrrhotite*) containing a small proportion of nickel. The ore is very largely used in America for the production of the nickel-steel used in the manufacture of ordnance. Specimens will also be found in case 123.

ARSENIC.

Case 89.

713, Andreasberg (Hartz Mountains) ; 9036, the Thames Native Arsenic. Old Field (New Zealand.)

Yellow sulphide of arsenic ; Hungary, Portugal, Moldavia Orpiment. 7440), and Utah.

3402 ; Sunshine Mine (350 feet), Mercur, Utah ; associated with free sulphur.

Red sulphide of arsenic, altering into orpiment ; Seattle Realgar. Washington, U.S.A.), and Nakety, New Caledonia.

Arsenical iron pyrites ; Canada, Virginia, Washington, Russia, Mispickel. Portugal, Saxony, and Cornwall.

8693 and 8643, Geyer, Saxony ; a radial variety known as *Geyerite*.

Samples of oxide of arsenic, as prepared from Cornish Mispickel, are shown.

BISMUTH.

Case 89.

From Queensland (Mount Shamrock), Tasmania, Cornwall, Native Bismuth. and Saxony.

8697, Geyer, Saxony, in quartz ; 8696, Geyer, Saxony ; in triplite (the reddish mineral) with quartz.

8716, Zwitterstock, The Erzgebirge, Saxony ; on the face of a quartz vein traversing granite—the variety known as *zwitter*.

Saxony is the principal bismuth-producing district of the world.

- carbonate.** Queensland (Mount Shamrock, Eukalunda), Tasmania (Bell Mountain, where it is associated with tinstone).
- bismuthine.** From Queensland (Eukalunda, where it is accompanied by pyrite), South Australia, Tasmania, Cornwall, Saxony.
- 6277, Fowey Consols Mine, Cornwall (the best specimen in the Museum); acicular crystals of *bismuthine* bridging across cavities; copper pyrites is present.
- 7247, Mount Black, Tasmania; in small needle-crystal, associated with copper pyrites, fluor, and quartz.
- 8685, Altenberg, The Erzgebirge, Saxony; lining a crack traversing granite—the variety known as *zwitter*.
- 4559, Ukalunda, Queensland; good crystals.
- illianite.** Sulphide of lead and bismuth, 10366, Mt. Farrell, Tasmania —

CHROMIUM.

Case 90. Is extensively found in New Caledonia, occurring, as usual, in irregular masses in serpentine. The deposits are represented by specimens of the ore and of the country rock. Although a black mineral, it sometimes reddens on weathering (8842). New Zealand, Queensland, Norway, Canada, and Hungary are also represented.

crocoisite. The combination of chromium with lead and oxygen, known as *crocoisite*, is perhaps the most beautiful mineral in Nature. The exceedingly handsome specimens from the West Coast of Tasmania, and the delicate crystals, of elongated habit, with perfect terminations will be admired by all. The beautiful blade-like crystals are very fragile and will not bear handling. Russian specimens are also exhibited.

Case 90.

MANGANESE.†

pyrolusite. Soft crystallised peroxide of manganese. Queensland, Canada, Russia, Andalusia, Thuringia. 3540 and 607, Nova Scotia, show the acicular crystals well.

* For uses of chromite, see page 88.

† For descriptions and uses of manganese ores, see page 87.

Hard massive variety of oxide of manganese. (See page 87.) **Psilomelane.**
Virginia, Queensland, New Zealand, Sweden, Merionethshire
(with carbonate), Westphalia, Spain.

Earthy peroxide of manganese. Arizona, The Caucasus. **Wad.**

Crystallised sesquioxide of manganese. The Harz. **Manganite.**

Carbonate of manganese. Colorado (crystallised), Tasmania, Rhodocrosite.
France.

Silicate of manganese. Russia, New Jersey.* (See also **Zinc Rhodonite.**
case 87.)

See under **Zinc.** **Franklinite.**

The Spanish and Caucasian ores are of special importance, so
much of the world's supply of manganese coming from those
sources.

URANIUM.

Case 90.

Uranium ores are used in staining glass and also in photo-
graphy; they are scarce and valuable.

Uranium ochre (709) and *pitchblende* (711) from Cornwall are { **Ochre.**
exhibited. { **Pitchblende.**

Hydrous sulphide of uranium. 3447, Colorado. **Johannite.**

3478, South Dakota. **Uran. Phosph.**

TUNGSTEN.†

Case 90.

Iron-manganese-tungstate. Queensland, Tasmania, Cornwall, **Wolfram.**
Saxony. 8656, 8651, two crystallised specimens from the
Erzegebirge. Until recently all the wolfram used in the Arts
came from the tin mines of Cornwall and Saxony.

Lime-tungstate. Victoria, New Zealand, Russia, Saxony. **Scheelite.**
The specimens from Zinnwald, The Erzegebirge, Saxony, show
small crystals (*octahedra*). 8677, from the same place, shows
scheelite traversing wolfram in net-like fashion; it has evidently
resulted from the alteration of the latter mineral.

Manganese-tungstate. Nevada (3858), Colorado (3446). **Hübnerite.**

Iron-tungstate. Colorado, 8019. **Ferberite.**

* The variety from New Jersey contains zinc, and is known as *fowlerite*.

† For description and uses of these ores, see page 89.

base 90.

MOLYBDENUM.*

molybdenite. Sulphide of molybdenum: Russia, Canada, Saxony.

base 90.

TITANIUM.

tile.

Oxide of titanium.

7320, 1251, crystals from South Australia. The small crystals show the characteristic form moderately well.

6106; Vermont, U.S.A.; in strings traversing rock-crystal.

6124, 3054; massive *rutile* from Norway and Russia respectively.

stone.

Silicate of titanium and lime; a wedge-shaped mineral, frequently found in granite and syenite, and sometimes mistaken for rutile. It has some commercial value. The specimens are from Canada and the Northern Territory of South Australia.

ovskite.

Titanate of lime and iron; a rare mineral, crystallising in well-formed cubes.—6910, Russia.

base 92.

ALUMINIUM.

This beautiful metal, characterised by its extreme lightness, is well known; nevertheless, the variety of uses to which it can now be put, as exemplified by the exhibit of manufactured articles exhibited here, will no doubt be a surprise to many.

Aluminium is, next to oxygen and silicon, the most abundant element in the earth's crust. It enters into the composition of innumerable minerals, usually in combination with silica; every common clay, for instance, contains a high percentage of it. The metal *can* be extracted from any of its compounds, but in its silicate condition this extraction is much too difficult and costly for commercial purposes. In practice only two ores are used, viz., *bauxite* and *cryolite*. The process of extraction is an electrolytic one; consequently aluminium works are situated in districts where a good fall of water for generating power can be had.

* For uses and description, see page 87.

A curious earthy mineral, consisting of hydrated alumina *Bauxite*. and, in most cases, a varying amount of ferric and titanic oxides, silica, &c. In its purest form it usually has a pisolitic structure, well shown by some of the Georgia ore (3558). The name is derived from the French district of Baux, where deposits occur.

4154, France; pisolitic red variety.

7534, Antrim; white variety.

Fluoride of aluminium and sodium. Cryolite has a characteristic Cryolite. appearance, from which its name is derived. It is one of the very few minerals that will melt in a candle flame. It occurs in quantity in Greenland only, where it is extensively quarried.

3847, Greenland.

3214, Pikes Peak, Colorado.

6847, *Mellite* (hydrous mellate of alumina), Russia.

TELLURIUM.

Case 92.

Tellurium is a rare element, closely allied to sulphur in its chemical characters. It is very exceptionally found as *native Tellurium*, but more usually occurs combined with *bismuth, gold, and silver*. Tellurium is of special interest, because of its frequent association with gold.

A constant characteristic of tellurides is their softness; they are all readily scratched with the point of a knife, and some with the finger-nail. In appearance they are all metallic.*

A number of ores from Cripple Creek, Colorado, are placed here for convenience (see page 105).

3444, 3464, Colorado.

Silver telluride.

6464, Tuolumne County, Colorado.

Tellurides of gold and silver. 6463, Tuolumne County, *Petzite* and *calaverite*. Colorado: *calaverite*, with much free gold.

Native
tellurium.
Hessite.

* A simple chemical test for a telluride is to put a speck of the mineral with a few drops of strong sulphuric acid in a porcelain dish—a saucer will do very well—and *gently* warm it over flame, taking care that the heat is not great enough to cause fumes to come off. If tellurium is present in any quantity, carmine-coloured streaks will appear in the liquid tailing off from the speck.

8466, Boulder Perseverance Mine, Kalgoorlie, West Australia: *calaverite*.

8762 (and others), Australia Mine, Kalgoorlie; a massive piece of *calaverite* showing the pale-brass colour of the mineral well. Pieces like this contain about 45 per cent. of gold and 1 per cent. of silver.

8430, Australia Mine, Kalgoorlie.

Sylvanite. Telluride of gold and silver. Called *graphic tellurium*, on account of the crystals often having a linear arrangement, somewhat resembling writing.

8622, Cripple Creek: rich ore with purple fluor.

8625-7, Cripple Creek: roasted ore from which gold has been sweated out.

Kalgoorlite. A telluride of gold and mercury. **8761**, Kalgoorlie.

Tetradymite. Bismuth telluride. **8522**, Dunallan Mine, Coolgardie; with quartz.

Case 92.

RARE ELEMENTS.

Allanite. A variety of epidote containing cerium. **6968**, Amherst County, Virginia.

Cerite. Silicate of cerium with lanthanum &c. **3056**, Sweden.

Columbite. Columbate and tantalate of iron and manganese. **3455**, Amelia, Virginia.

Microlite. Tantalate of lime. **3476**, Amelia, Virginia.

Monazite. Phosphate of cerium, thorium, &c.

The mantles used in incandescent gas lamps are now made largely of oxide of thorium; consequently, varieties of monazite, containing an appreciable percentage of this substance, are in some demand. Monazite-bearing sands are not of exceptional rarity, but the proportion of thorium present is sometimes low. It is procured principally from the Atlantic States of North and South America.

Monazite is resinous in appearance, brownish in colour, and can be scratched with the point of a knife. The specific gravity (5, or a little over) is of great assistance in determining the mineral.

3445, Amelia, Virginia. **7713**, Delegate River, Victoria: sand.

8156, 8157, Washington Heights, New York : minute crystals.

Silicate of vanadium; a very rare mineral, said to always carry **Roscoelite**.
old. 1279, 3873, Granite Creek, El Dorado County, California.

8552, country rock of the Lady Charlotte Mine, Kalgoorlie, **Vanadium**.
 West Australia : stained with vanadium.

A sulpho-vanadate of copper has recently been found in South
 ustralia.

Sulph-arsenide of thallium. **6671**, Alchar, Macedonia. **Lorandite**.

3893, Selen-tellurium with durdenite, Honduras. **Selenium**.

8291, metallic : artificially prepared.

PHOSPHATES.

Case 91.

The large amount of phosphoric acid withdrawn from the soil
 plant-food has rendered the use of phosphatic manures indis-
 pensable. Natural phosphates have now been found in most
 parts of the world; they vary much in appearance and character,
 and, being generally of an earthy nature, their recognition is
 not easy.

Before natural phosphates can become available for plant-food
 they generally have to be treated with sulphuric acid, which
 converts the phosphate of lime into a soluble condition. The
 slings from the converters used in treating phosphoric iron-
 ores are of great manurial value.

Crystalline phosphate of lime—*apatite**—occurs in veins in **Rock**
 Canada, Norway, and elsewhere, but the cost of mining is such **Phosphate**.
 that the deposits are not now remunerative. Rock phosphate
 occurs in ancient crystalline rocks.

7488, 7159, green and red varieties respectively of Canadian
 rock phosphate.

6175, Norwegian rock phosphate.

In France, Spain, Russia, and England, extensive deposits of **Other**
 nodular phosphate of lime occur; these are of sedimentary **Phosphates**.
 origin. In Florida and Carolina immense beds are found,
 variously known as "land," "river," or "pebble" phosphates,

* See case 102, page 160.

according to their mode of occurrence ; these are of Tertiary age, and sometimes contain organic remains, replaced by phosphate of lime.

The West Indian varieties (Sombbrero, Redonda, &c.) contain fragments of bone ; they run rather high in alumina and iron.

7485, Spanish phosphate, containing 39 per cent. phosphoric acid.

7491, Connétable „ „ 38 „ „

7487, Redonda „ „ 37 „ „

7484, Sombbrero „ „ 34 „ „

7486, Tennessee „ „ 80 „ „

7490, Peace River „ „ 28 „ „

7492, Land pebble „ „ 33 „ „

7489, Florida, hard rock phosphate, containing 36 per cent. phosphoric acid.

Phosphatised sharks' teeth, shells, reptilian vertebræ, &c., from Florida are also shown.

From Ocean and Pleasant Islands, near the Equator in the South Pacific, are exhibited ; various forms of coral and coral-rock, replaced by phosphate of lime ; oolitic, pisolitic, stalactitic and stratified forms are represented.

The replacement of the carbonate of lime of the original coral by phosphate of lime is very perfect, such pseudomorphs as those in case 113, page 171, being very perfect.

Rock phosphates have recently been found in South Australia.

Case 93.

CARBON.

Hydrocarbons. *Ozokerite* ; a mineral wax found in bunches in the oil-bearing strata of Galicia. Specimens of the crude and refined material are shown.

Kauri Gum ; new Zealand. A polished piece will be found in pyramid case 103.

Retinite ; a fossil resin, somewhat similar to amber.

8786, Macquarie Harbour, Tasmania, where it occurs in lumps scattered through a bed of lignite.

9478, 3158, in coal, New Zealand.

Asphaltum, or Mineral Pitch; a mixture of various hydrocarbons, often found occupying small lakes. Specimens from Cuba, Trinidad, France, Russia, and California. Pictures of asphaltum mining in California will be found on the east wall.

Elaterite, or Elastic Bitumen; dark-coloured elastic masses, resembling ozokerite in composition. Drifted boulders are found on the shores of Glenelg (South Australia, 5925) and of Tummock Island (Bass Strait, 8787). The source of which is not known.

Gilsonite; Utah (8401). Gilsonite is of great value in the preparation of certain varnishes.

Albertite; Canada (3143).

Bituminous Limestone; France (9990-1).

Petroleum Oil; EASTERN STATES OF NORTH AMERICA. The oil occurs in the Trenton Series, which is of Upper Silurian age. The strata are only slightly inclined. The oil-bearing beds are reached by deep wells, the oil rising by hydrostatic pressure. The oil occurs in elongated areas lying parallel to the Appalachian chain. In Virginia these areas have been shown to be along the crests of the folded strata. The oil, which is undoubtedly becoming exhausted in some centres, is supplied to industrial works by an extensive system of piping.

6951, 6946, 6944, 6941, bituminous limestones from various places.

6945, Illinois; a geode of quartz and chalcedony saturated with oil.

6952-5, oil-bearing sands, principally from Virginia.

CALIFORNIA.—The basis of the Californian oil is *asphaltum*, not *paraffin* as in the Eastern States. The oil occurs in highly tilted strata of Tertiary age, thus differing widely from the Eastern occurrence; in consequence it does not rise to the surface naturally, and has to be pumped.

6949, asphalt rock, Buena Vista.

6480, hydrocarbons condensed on the timbers of a tunnel driven for oil.

6475, argillaceous bituminous limestone with fossils of Eocene age. This overlies the oil strata.

6479, drill core, showing Tertiary fossils. The associated shales and sandstones are also shown.

5972, Tar Point, Canada: igneous rock, showing patches of petroleum.

3162, Gisborne, New Zealand: crude oil.

Oil shales from Kentucky and Scotland, including the original *torbanite* (5916) from Torbane Hill, Edinburgh.

Tasmanite, Tasmania (3156).

An oil-bearing shale of no present commercial value. Under the microscope it is seen to contain numerous lens-shaped bodies of vegetable origin.

Peat—A carbonaceous deposit resulting chiefly from the accumulation of moss (*sphagnum*) in small lakes. Its occurrence is confined to temperate regions. Scotland, Russia, Scandinavia.

Lignite—A transition stage between vegetable matter and true coal. Victoria (Morwell), South Australia (Leigh's Creek), West Australia, New Zealand, Devonshire, Russia.

Cannel Coal—Great Britain, America.

Jet—Whitby.

Case 94. *Bituminous Coal*—Queensland, Tasmania, New Zealand, Victoria, West Australia, India, South Africa, Borneo, New Caledonia, Great Britain, Germany, Argentine Republic, United States. The coke manufactured from some of these coals will be found in pyramid case 107.

Anthracite.—Wales, Russia, Pennsylvania, and other American localities. See case 103 for a fine block of Pennsylvanian anthracite.

Graphite—Ceylon, Canada; also in crystalline rocks from Russia.

MISCELLANEOUS.

Case 91.

Corundum, oxide of aluminium, Al_2O_3 , and an impure black variety containing iron ores, known as *emery*, are largely used as rasives. They are now, however, being superseded by *rborundum*, a silicide of carbon, artificially produced at Iagara Falls, which is harder than any natural substance other than the diamond.* Emery is produced principally in Asia Minor (7514) and Greece (9979).

Corundum,
Emery.

9001, crystallised carborundum.

Varieties of corundum, not of commercial value, will be found among the oxides in case 99.

Wyoming.

Alum.

Washington.

Crystal Sand.

Rhiwlas, North Wales.

Rhiwlas
Earth.

Gloucestershire (Eng.)

Building
Stones.
Ornamental
Stones.

Williamsite, a variety of serpentine ; Maryland marbles.

Onyx marble† ; a variety of calcareous tufa (travertine), showing various markings and colouration, and capable of receiving a good polish : California. The best varieties come from Mexico, where it is associated with hot springs.

Cornwall, Russia, North Carolina, Canada, Tasmania.

Kaolin.

In addition to kaolin itself, the Cornish exhibit includes various qualities of the disintegrating granite from which it is derived.

Native Sulphur frequently results as a product of volcanic action. Large quantities are won from the crater of Etna (Sicily). A pyramid case 108 will be found a series of specimens showing the crude Sicilian sulphur, and the commercial varieties

Cases
91, 122,
108.
Sulphur.

It is stated that a carbide of titanium has now been prepared, which is harder than diamond.

† The true onyx is a very different mineral—a variety of chalcedony.

produced by its refinement, with their approximate values - A large specimen of native sulphur, formed during a recent eruption of Tarawera (New Zealand), is also placed here. In **case 91** will be found crystallised (9450) and massive varieties (735) from Sicily, massive from Russia, siliceous from Utah (8557), and auriferous (2 dwt. per ton) from Colorado (8558).

Much of the sulphur of commerce is obtained by the roasting of pyrites ores. In **case 122** will be found a small series from Spain, showing copper-pyrites ore, with the products resulting from its treatment.—metallic copper, slag-wool, crude sulphur, refined sulphur ("flowers" and "rolled"), and bluestone (sulphate of copper).

Cases 141, 105. Mica as a rock-forming mineral is referred to on page 148. When obtainable in large, thin sheets, mica is of great value, being used in electrical and other work. The scrap mica from the mines is used up in a great variety of ways. It has been found of commercial quality in the Macdonnell Ranges in Central Australia, and possibly one or two other places but is only mined at the former locality in Australia. Good specimens, in small sheets, are shown from West Australia, including the lithium variety from Coolgardie (see page 148).

The mica of commerce comes principally from Canada and India; and, in addition to these countries, from the United States (Idaho and South Dakota).

Case 141. "Asbestos" refers in commerce to certain minerals that are sufficiently fibrous, tough, and flexible to admit of being woven. Varieties of hornblende and of serpentine both fulfil those conditions, and both are included under "asbestos." The most valuable property possessed by asbestos is its comparative indestructibility by fire, although different samples vary considerably in this respect. Many samples which appear good to the eye may be found, when submitted to practical tests, to be deficient in some quality—very commonly in toughness.



DOUBLY-TERMINATED QUARTZ CRYSTAL, KINGSGATE.

The asbestos of commerce comes from Canada and Italy, with much smaller supplies from some other districts. In New South Wales, a few tons of good material were procured at Jones Creek, Gundagai, a few years ago: none has been procured since, or elsewhere.

Italian asbestos is characteristically long in fibre, while the Canadian is comparatively short. In lode-case 128 will be found a specimen illustrating well the mode of occurrence of asbestos in Canada: a vein of it is seen traversing serpentine. Commercial samples of Canadian asbestos are exhibited here, ticketed with their values per ton in 1900. On the east wall is a small case containing a variety of articles manufactured from asbestos.

Samples from Italy, Canada, Oregon and Wyoming, also from Gundagai, Rockley, Tamworth, Burrowa, South Australia, West Australia, and New Zealand.

These have been referred to to some extent under *corundum* Case 110. and *emery* (page 131). *Garnet* is also sometimes made use of Abrasives. for this purpose.

Pumice: Teneriffe, Messina, New Zealand.

The frothy portions of lava-streams. The procuring and preparation of pumice is an industry of considerable importance in the Lipari Islands (Italy). The pumice is obtained from galleries driven into the lava, and, after drying, is graded according to size. Pumice is used principally for polishing purposes.

*Tripoli**: a remarkable porous siliceous rock found in Missouri. Owing to its porous nature, it is used as an absorbent as well as for abrasive purposes.

Tripolite (Kieselguhr, Diatom Earth), see page 96.

New Zealand, Victoria, Germany.

* Diatom Earth has also been known as "tripoli." The Tripoli of Missouri does not consist of organic remains.

The Victorian tripolite is of exceptionally fine quality, both as regards colour and texture. The German earths have an admixture of carbonaceous matter which, when once ignited, emits enough heat for drying purposes. For New South Wales earths, and remarks on tripolite, see page 96.

Barium.

Salts of barium are used in the arts, and the sulphate, *barytes*, is employed with white lead in the manufacture of paint. *Witherite*, the carbonate of baryta, occurs in the north of England; it has not been found in New South Wales. *Barites* is of common occurrence in mineral veins. It is of commercial value only when of great purity, and perfectly white in colour.

Plumbago.

Black Lead, Graphite—Carbon with more or less impurity. Used for crucibles, pencils, lubricating, stove polishing, foundry and other purposes.

Ceylon, Russia, Mexico, Bohemia, Queensland.

Ceylon is the principal source of graphite of high quality. The purest material (96 per cent. carbon) is used for crucibles, while the very finest, after sifting through silk sieves, is employed in stereotyping and for lubricating. Graphite containing 70 per cent. carbon is used for foundry and general purposes. The Mexican graphite (87 per cent. carbon) is used for stove polish and for pencils. The Bohemian (60 per cent. carbon), for foundry work and stove polish.

Case 106.
Cement.

Portland Cement, without entering into details, is a material resulting from the calcination, carried to the point of incipient fusion, of an intimate admixture of calcareous and argillaceous substances. After calcination the material is ground to the fineness of flour—90 per cent. passing through a 5,800-mesh sieve. Some of the crude materials used in the manufacture of Portland Cement in Great Britain are exhibited. By an admixture of chalk (carbonate of lime) with the various clays and muds used, any desired combination can be arrived at.

Analyses of some of the raw materials and of the cements will be found in the case.

Cements may be either slow- or quick-setting; a slow cement taking two hours or more. By long storage it becomes slower in setting and increases in tensile strength. They are generally used with more or less sand. The tensile strength is determined by the breaking of test briquettes, some of which are exhibited.

Exhibits from the Cullen Bullen Companies, of New South Wales, in addition to those from foreign localities, are placed here.

Roman Cement is one of the quick-setting class, becoming hydrated in a few minutes. It is prepared from the calcareous clay nodules so abundant in the *London Clay Formation* of the E. of England. It is not nearly equal in strength to the Portland. The septaria are crushed, strongly calcined, and powdered. Septaria from different localities are frequently mixed. Magnesia is quite harmless in these quick-setting cements.

Plaster of Paris, Parian Cement, &c.

Patent Fuel, England. The patent fuel is prepared from very small, cleaned coal. The latter is crushed and mixed with 9 to 10 per cent. of pitch prepared from coal tar.* After subjecting to hot air or steam to soften the pitch, the material is moulded into briquettes by hydraulic pressure. The whole operation is automatic. **Case 107.** **Patent Fuel.**

The briquettes are harder, and require much less space for packing, than coal.

Coke from England and the United States.

Coke.

Large deposits occur in some of the Midland counties of England. The salt is generally converted into brine and pumped to the surface. Brine and prepared salt in different stages for various purposes, is exhibited. **Case 108.** **Rock Salt.**

Borax, borate of sodium, California.

Borates.

Priceite, borate of lime, Oregon.

* After extracting the pitch, carbolic acid, &c., can be obtained from the residue of the coal tar.

- Pandermite* and *Colemanite*, borates of lime, California.
- Ulexite*, borate of lime and soda, California.
- Soda Nitre. Nitrate of soda, Chili.
- Stassfurt Salts. A deposit of soluble salts, associated with rock salt, occurs in great variety at Stassfurt, in Germany. Some of these are of considerable value for agricultural and other purposes.
- Kainite*, hydrous sulphate of magnesia with chloride of potassium.
- Kieserite*, hydrous sulphate of magnesia.
- Glauberite*, hydrous sulphate of lime and soda.
- Krugite*, hydrous sulphate of lime, potash, and magnesia.
- Carnallite*, hydrous chloride of magnesium and potassium.
- Sylvine*, chloride of potassium.
- Boracite*, borate and chloride of magnesium.
- Rubidium alum*, &c.
- Sulphate of Soda. California.
- Epsomite. Stassfurt, Wyoming.
- Sulphur. Sicily, crude sulphur and products.
- Case 106. China Clay, Staffordshire potteries.
- Clays, &c. Raw materials, intermediate products and manufactured articles.
- Fire Clays*, Kentucky, Virginia, Glenboig, Durham (Eng.), Sheffield, Leeds, Stourbridge, New Zealand, Victoria (Morwell).
- The refractory material from Sheffield is called *gannister*; it is very siliceous, and has great heat-resisting powers.
- Clays from New South Wales are contained in case 76 (see page 96).
- Magnesite*, Austria, with manufactured brick; used for heat-resisting purposes.
- Steatite*, Carolina (see page 149).

ROCK-FORMING MINERALS.

The non-metallic minerals that compose igneous and other rocks are arranged in seven cases (95-101) immediately following the foreign metallic series. These are for the most part *silica* or *-silicates*, and seldom have any appreciable commercial value. They comprise a large number of varieties, and are conveniently arranged into the following groups:—

- I. Minerals composed entirely of silica (case 96 and part of 95). *e.g.*, *quartz*.
- II. Minerals consisting largely of silicates of alumina, with potash, soda, or lime, *e.g.*, *felspar* (cases 95 and 97).
- III. Minerals consisting largely of silicates of iron and magnesia, *e.g.*, *mica* (cases 97 and 93).
- IV. Miscellaneous silicates and oxides, *e.g.*, *garnet* (case 100).
- V. Sulphates (case 99).
- VI. Carbonates (case 101).
- VII. Fluorides and phosphates.

Very many of these minerals may also occur as gangue material in lodes, and many of the most perfectly crystallised specimens have been so formed.

The great proportion of rock-forming minerals contain silica and alumina; so great, indeed, is this proportion, that it is estimated that silicon constitutes one-half of the crust of the earth, and aluminium one-fourth, leaving only the remaining fourth for all the other elements.

The rock-forming minerals are all placed together, so that specimens from New South Wales and other localities will all be found in these cases.

GROUP I.

Minerals composed entirely of silica.

Case 96.

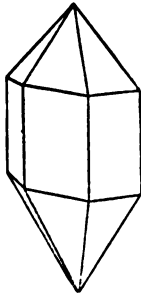
CRYSTALLISED SILICA.

Quartz.

Quartz is the most common of all minerals. It assumes various forms and colours, is frequently beautifully crystallised,

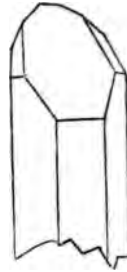
and altogether constitutes most attractive specimens. As gangue material for mineral lodes it is well known to the miner. Many specimens of lode-quartz will be found in the gold and other exhibits.

The most important physical characteristic is its *hardness*—it takes the edge off the best steel, and scratches glass with readiness. Its crystalline form is very characteristic, consisting essentially of a six-faced prism capped by a six-faced pyramid. By means of this crystalline form glassy quartz crystals can be distinguished from diamonds with certainty and ease: *the hardness of quartz is six-faced, that of diamond four-faced.*



Doubly-terminated crystal
of quartz.

A



Quartz crystal with the pyramid
faces unequally developed.

B

It generally happens that crystals of quartz grow inwards into a cavity, one end only being developed; occasionally, however, a crystal grows in a prostrate position, in which case both ends may be fully formed. A remarkably fine doubly-terminated crystal from the Kingsgate bismuth mines near Glen Innes is contained near this case (see Plate VI, and a smaller specimen in case 143).

Small specimens are exhibited from Pennsylvania, Mount Remarkable (S.A.), Boorolong, Kingsgate (Glen Innes) Broken Hill (5547, Consols Mine, resting on calcite), and New England.

Small doubly terminated quartz crystals with a very short prism, are of frequent occurrence in porphyry.

Crystallised quartz showing one termination only is exhibited from many localities; in particular from the Dutchman's Lode (tin), New England, from the hematite mines of Cumberland (Eng.), and the lead mines of Weardale (Eng.). Those from Cumberland are associated with specular iron.

Quartz crystals vary much in their *habit* without losing the general characteristics above described. Thus, 5891, Bora Creek, and 8027, New England, show a long slender prism, while 6985, America, has a prism, but slightly developed compared with the pyramid. The excessive development of certain crystal faces leads to distorted forms (see fig. B on page 138). Thus in 4000, Fish River Creek, two parallel faces of the prism have grown to a much greater extent than the other four, giving rise to a tabular form.

9076, Kingsgate: shows one crystal invested by another. The inner crystal is of earlier date than the outer. It would appear to have ceased to grow for a while, and then to have resumed its growth when favourable conditions again prevailed.

Quartz very frequently contains inclusions of other minerals. The Cumberland specimens above alluded to contain *hematite*. 97 and 9173, Kingsgate: contain respectively *mispickel* and *native bismuth*. 95, Vermont, U.S.A.; 7444, Madagascar, and the Cairngorm, 8735, Tingha: contain strings of *rutile*.

Quartz may be coloured by pigments:—6970, Glen Innes: red. 1749, Broken Hill, and 6840, Russia: blue. 94, Moonbi, and 5181, Werri Creek: green.

Enhydros.—These consist of *quartz* or *chalcedony*, or both. They are hollow, frequently containing a liquid; and are not true crystals or pseudomorphs. Magnificent specimens have been found at Kingsgate, but the museum does not possess one. Those exhibited (5902, 5162) are from Spring Creek, Beechworth, Victoria.

Cairngorm.—Smoky quartz: Uralla, Tingha, Umeralla, Kingsgate, Solferino, Meadow Flat, and elsewhere.

88, Uralla: shows doubly-terminated crystals lying on and partly embedded in orthoclase felspar.

Amethyst.—Mexico, Cornwall, New Zealand, Victoria, Pennsylvania, Wellington, Abercrombie River, Sidmouth Valley (near O'Connell). The amethyst sometimes merely forms an envelope to normal white quartz. This is the case with the Sidmouth Valley specimen, 3793, and that from Oban in case 144. See also case 121.

Rose Quartz.—South Dakota (also in case 119); Russia.

Eisenkiesel.—A spotted variety of red quartz. 932, Fairfield.

Chalcedony.

PARTIALLY CRYSTALLISED SILICA.

Agate.—Banded chalcedony. Tamworth, Wee Waa, Singleton, Boggabri, Cowra, Narellan, Bowning. Lismore, Tweed River, Cooma. Many of these have been cut and polished, and among them are some of considerable beauty. Agate generally originates from the deposition of silica as successive linings on the interior of cavities in lavas such as basalt and rhyolite. This is notably the case with the Boggabri and Tweed River agates. They therefore have the same shape as the cavity in which they were formed. It is only when they are cut across that the concentric or banded structure, to which agates owe their beauty, is revealed.*

113, Tamworth, *fortification agate*: so-called from the zig-zag form of the bands.

Ordinary *chalcedony* is shown from Boggabri, Murwillumbah, Tweed River, Ph. Tilbuster. Several specimens, notably 2593, Murwillumbah, show the characteristic mammillated form of chalcedony well.

2686, Richmond River: the variety known as "water-stone." These are hollow, and can sometimes be seen to contain a liquid.

3607, Angastan, S.A.: the spongy variety known as "float stone."

Jasper.—An opaque variety.

* The colouration of agates can be much modified by artificial treatment.

Lord Howe Island (several colours), Nundle, Cooma, Bald Hills (Byrock).

3946: silicified spherulitic rhyolite, now almost in the condition of jasper. The rock has been replaced, molecule by molecule,* by silica, without losing its original structure.

5568, Broken Hill, with malachite: the red jasper and the green malachite form an effective combination.

HYDROUS NON-CRYSTALLINE SILICA.

Case 95.

Specimens of *precious opal* will be found in Gem Cases 48 and Opal.

~~28~~ Common opal is exhibited from Cowra, Gundagai, Balranald, Whitecliffs, Glen Innes, Tamworth, Barraba, and elsewhere.

10111 and 3742, Whitecliffs Opal-field: showing the association of common and precious opal.

3979, 3981, Balranald: showing the transition, under atmospheric agencies, of opal into opaque earthy silica: material like this is liable to be taken for kaolin.

Hyalite.—A transparent form of opal occurring somewhat like drops of dew. It occurs principally in igneous rocks, *e.g.*, the specimens from Mullumbimby and Ben Lomond.

9269: a pretty blue variety from the capping of the Brown's Creek Lode, Blayney. A specimen from the Gwydir River also exhibited.

Menilite.—An opaque liver-like variety occurring in the gypsum-bearing marls near Paris (9702).

Compact forms of silica, sometimes very impure, occurring in limestones and other sedimentary rocks. Flint is very common in the Chalk Formation of Europe. It was used by prehistoric man for making weapons and implements, since it breaks with sharp cutting edges. Flint-Chert.

In addition to Chalk flints, there are specimens from Pambula, Wallsend, Capertee, South Australia, and New Zealand.

* In Structure Case 113, is an instructive specimen from Boggabri (9040) showing a spherulitic rhyolite that has undergone partial replacement by chalcedony, a core of comparatively unaltered rock still remaining.

Pseudomorpha. Silica is very frequently found replacing other substances, the replacement being sometimes so gradual that the structure of the original may be perfectly preserved. This is frequently the case with wood, the cell-structure being sometimes almost as perfect as in the wood itself. It is well shown in some of the specimens chosen for exhibition. Silicified, or petrified wood, as it is often called, is of very common occurrence in New South Wales.

8699, Schneeberg, Saxony: quartz pseudomorphous after *barytes*.

8654, Schneeberg, Saxony: quartz pseudomorphous after *calcite*.

3191, in case 119, Florida: coral replaced by chalcedony.

Numerous other cases of replacement by silica will be found in Structure case 113.

GROUP II.

95. Minerals consisting largely of silicates of alumina with potash, soda, or lime.

FELSPAR.—The great group of minerals known as feldspars is of the very greatest importance in the composition of igneous rocks. The group comprises a great many varieties differing in chemical composition, crystallographic form, and even in physical properties. They all contain silica and alumina; and a convenient classification is that which depends upon what other silicates are present. Thus we have

Orthoclase:—Silica, alumina, potash.

Albite:—Silica, alumina, soda.

Oligoclase:—Silica, alumina, soda, lime.

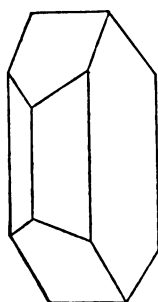
Labradorite:—Silica, alumina, lime, soda.

Anorthite:—Silica, alumina, lime.

They all agree in readily cleaving into little flakes, and in being just scratched with a good knife.

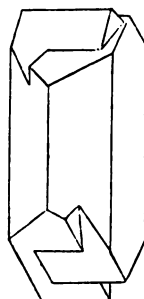
Orthoclase. This is found in granites and syenites, or veins traversing them, in porphyries, and in rhyolite. It is usually pink or creamy

in colour. A green variety, however, occurs at Broken Hill (6696, 5179) and a blue* one at the Londonderry Mica Leases, Coolgardie (8794). The crystalline form of orthoclase is very characteristic, but is not very well shown by the specimens exhibited (see Fig. A). The crystals are very frequently found twinned, the usual appearance being as if one half had been spun round through an angle of 180° (fig. B). This twinning is indicated by a division line passing down the faces of orthoclase crystals as seen on a fractured surface of an igneous rock. 168, from Uralla, is such a twin crystal, with crystals of smoky quartz imbedded in it. Under the influence of weathering it passes into kaolin (see p. 131). Both orthoclase and kaolin are used in pottery making. Coolgardie, Cooyal, Grafton, Braidwood, Timbarra, Broken Hill, Wilson's Downfall, and other localities.



A

A—Simple crystal of orthoclase.



B

B—Twin crystal of orthoclase.

5178, Broken Hill, shows the cleavage of orthoclase well.

8392, Gulgong, etc. ; red felspar in granite.†

8877, Port Victor, S.A. ; crystals of orthoclase that have had their angles eaten away (*corroded*) by the igneous magma in which they are imbedded.

* As this blue colour disappears when the mineral is heated, it is probably due to organic matter.

† Crystals of orthoclase sometimes attain a very large size, and impart a very ornamental appearance to the rock. Granites depend for their characteristic colour upon the tint of the orthoclase present.

Orthoclase is generally dull in appearance by reason of the formation of a small quantity of kaolin, but when perfectly fresh it may be as clear and glassy as quartz. A tabular form of clear orthoclase, of common occurrence in the lava trachyte, is known as *sanidine*. 7701, Wantialable Creek; *sanidine* crystals picked out from a trachyte tuff.

Moonstone, is an opalescent variety.* 6107, from St. Lawrence County, New York.

Perthite. *Orthoclase* intergrown with *albite*, the complex nature of the mineral being indicated by its streaky appearance—Canada, Pennsylvania.

Microcline. A variety differing very slightly from true orthoclase in crystalline form† The beautiful green feldspar from Virginia, Russia, and California, known as *amazon stone*, is microcline. 143, Russia; this shows the crystal-form better than any of the specimens of true orthoclase exhibited.

8795, Coolgardie; *orthoclase* and *microcline* intergrown.‡

3190 (in case 120), California; a group of crystals.

The remaining feldspars very commonly show a parallel striation on certain faces, which is due to twinning. They are grouped together as “*plagioclase*.” This striation can frequently be seen on the faces of feldspar crystals in igneous rocks, and is of great assistance in distinguishing them from orthoclase.

Albite. Virginia, Russia.

Oligoclase. Ytterby (Sweden), Canada.

Labradorite. Labrador. This feldspar possesses a beautiful blue “play of colours” on certain faces. It is found in great quantity in Labrador. As a rock constituent it is common in basalt.

FELSPATHOIDS.—A small group of minerals resembling feldspar in chemical composition, but differing in crystalline form. They are found in the lavas of certain volcanic areas, such as Vesuvius.

* Some of the South Coast granites, particularly these from Mount Dromedary and Moruya, contain opalescent feldspars, that approximate to moonstone.

† A certain crystal angle is 90° in orthoclase, but not exactly 90° in microcline.

‡ This intergrowth can only be satisfactorily detected under the microscope.

Silicate of alumina and potash. Pseudomorphs of felspar *Leucite*.
after leucite; Arkansas.

Hydrous silicate of alumina and soda.

Analcite.

Until recently it was believed that analcite is always a secondary mineral, but it is now known to be an original component of certain igneous rocks. It has been found by means of the microscope in some of the rocks round Sydney (see page 184).

Silicate of alumina and soda. Small crystals only, in rocks from Nepheline. Lue and the Snowy River.

Silicate of alumina and soda with sodium carbonate; Maine. *Cancrinite*.

Silicate of alumina and lime; characterised by its crystalline *Scapolite*. form, which gives essentially square outlines in cross section.*

St. Lawrence County (New York), Perth (Canada), Russia, Tasmania.

Silicate of alumina, lime, &c.; also characterised by essentially *Idocrase*. square sections. New England, Tasmania.

Silicate of alumina and soda with chloride of sodium; a pretty *Sodalite*. mineral, taking a good polish; frequently blue in colour. 3597, Dunganon, Ontario. *Sodalite* has recently been detected in rocks from near Lue.

Silicate of alumina, soda and lime with sulphide of lime. *Lapis Lazuli*. Frequently of a deep blue colour; a handsome, ornamental stone. Chili; Russia.

ZEOLITES.—In certain volcanic rocks, more particularly **Case 97.** scoriaceous basalts, secondary minerals very frequently form as a result of the chemical alteration of the rock. When cavities exist, these secondary minerals have room in which to develop their crystalline outline, and beautiful forms may result. The greater number† of the minerals formed in this way are hydrated silicates of alumina, with potash, soda, or lime, and they are all grouped together as *zeolites*.‡

Zeolites are very common in many altered basalts and allied rocks in New South Wales. The Survey collections include a good many of these, more particularly from the Northern

* A good crystal of scapolite will be found in **case 33**.

† Carbonate of lime and various forms of silica, *e.g.*, *agate* and *precious opal*, also occur in this way.

‡ This name refers to an apparent boiling-up when zeolites are heated in the blow-pipe flame; this is due to the large quantity of water they contain.

districts, but they have not been examined yet. They can be obtained occasionally in some of the quarries round Sydney.

- Prehnite.** Hydrated silicate of alumina and lime, differing from other zeolites in containing less water, and in its greater hardness ($H=6$). Fine specimens have been obtained at Prospect (Sydney Waterworks) and at Dapto, and are exhibited in case 144. On account of its hardness, prehnite takes a good polish; a polished piece is exhibited here.
- Phacolite.** In the basalt quarries of Melbourne a great variety of beautiful zeolites is obtained, a number of which are exhibited; in particular might be noted the pretty little *phacolite*.
- Stilbite.** Hydrous silicate of alumina, lime and soda. 5012, fine specimens from the Liverpool Plains.
- Natrolite.** Hydrous silicate of alumina and soda. Lochinvar; a magnificent specimen.
- In case 119 fine specimens of various zeolites from Nova Scotia.

GROUP III.

Minerals consisting largely of silicates of iron, magnesia, and lime.

- Case 97.** PYROXENE.—A group of silicates varying in composition. A number of good crystals from Canada here and in case 119.*
- Augite.** Silicate of lime, iron, and magnesia essentially; 813, Albury. Augite is sometimes found in lumps in basalt.
- Enstatite.** Silicate of magnesia; Bamle (Norway).
- Bronzite.** A fibrous enstatite, with a bronzy lustre; Consols Mine, Broken Hill.
- Jeffersonite.** Manganese-pyroxene; Franklyn (New Jersey).
- Diallage.** A fibrous pyroxene with a sub-metallic lustre; Gundagai.
- Spodumene.** Silicate of alumina and lithia; South Dakota. This mineral sometimes occurs in crystals of enormous size.

* A crystal of pyroxene, with crystallographic description, will be found in case 33.

Silicate of lime: A fibrous white mineral, very commonly found **Wollastonite**. in limestone, where altered by contact with heated igneous rock. In New South Wales it is sometimes associated with garnet, which has resulted from the same metamorphic action. (See **case 100**.)

Sidmouth Valley, Cox River, Newbridge, Macleay River.

AMPHIBOLE. A group of silicates differing essentially from the pyroxenes in crystalline form only.

Silicate of magnesia, lime, alumina, and iron, usually of a Hornblende. dark greenish colour, frequently occurring in blade-like crystals. (See **1241**, from Kapunda, South Australia, and **3679**, from Massachusetts.)

It is a common constituent of diorite, andesite, and other igneous rocks in New South Wales. Selected specimens from Carcoar, Fish River, Gundagai, and Glen Innes are exhibited. The syenite of the Gib Rock at Bowral sometimes contains patches rich in blade-like hornblende. (See **case 142**.)

9391, Barrier Range: crystals penetrating calcite.

A green variety of amphibole, poor in alumina, occurring in **Actinolite**. slender glassy crystals. Sofala, McIntyre Brook, and New England.

Silicate of lime and magnesia; grey in colour. It frequently **Tremolite**. occurs in limestones that have been altered by the intrusion of a mass of igneous rock (contact-metamorphism). Tumbarumba.

Consisting of matted fibres; Tasmania, South Australia. **Mountain**

A blue fibrous variety, becoming yellowish on oxidation, found **Cork.** in South Africa. When silicified, as is generally the case, it takes an excellent polish, and forms a beautiful ornamental stone. (See **case 15**.) **Crocidolite.**

Is often a fibrous form of amphibole (see **Serpentine** and page **Asbestos**. **126**).

A large specimen from Renfrew, Canada, is shown in **case 120**. **Jade.**

A very tough, massive silicate of magnesia and soda—the “greenstone” of New Zealand; a handsome ornamental stone. It has been found at the Wentworth Mine, Lucknow, but this variety does not take a good polish.

Case 98. MICA.—Silicate of alumina, potash, iron, magnesia, &c.—Another group of minerals with variable composition. Mica possesses a most perfect cleavage, by means of which sheets of large size and extreme thinness may be readily split off. The cleavage flakes are perfectly elastic. For specimens of commercial mica see cases 105 and 132 (page 132).

Muscovite. Potash Mica. West Australia, Ontario (green variety), Canada, Broken Hill.

867, Russia: a crystal showing the characteristic six-sided form.

Biotite. Magnesia Mica. Canada, Norway.

Zinnwaldite. A lithia variety of biotite. Saxony. Londonderry Mica Mine, Coolgardie.

Uranium mica. Saxony.

Phlogopite. Russia, Canada.

Fuchsite. Chrome Mica. New Caledonia, New Zealand, Russia.

Lepidolite. Lithium Mica. A beautiful rose-coloured variety.

Olivine. Silicate of magnesia with more or less iron. A mineral frequently found in crystals or granular aggregates in basalt. Bulli, Walcha, Inverell.

9034, in case 143: a block of basalt from Bulli, containing large masses of olivine and of hornblende.

Serpentine. Hydrated silicate of magnesia, resulting usually from the alteration of olivine, but sometimes of pyroxene and amphibole, as is frequently the case in New South Wales. Serpentine is of very common occurrence; it generally occurs intimately associated with other substances as a rock rather than as a mineral. It is sometimes used for ornamental purposes (see page 98). Cornwall (red variety from the Lizard), Gundagai, Port Macquarie.

Picrolite. A fibrous form of serpentine. Gundagai, Goulburn, New-bridge, Lucknow, Orange (Carangera Copper Mine). Other

specimens will be found in the New South Wales gold cases, particularly from Gundagai.

The asbestos of commerce is frequently a form of serpentine (see page 132). New Caledonia; Maryland.

Asbestos.
Precious
Serpentine.

GROUP IV.

Miscellaneous silicates and oxides.

Hydrous silicate of magnesia, alumina, and iron. A dark-green mineral, frequently with a very perfect cleavage resembling that of mica. The cleavage-flakes are flexible but not elastic. Chlorite. Chlorite can be distinguished from most micas, as it can be easily scratched with the thumb-nail; true micas cannot. Prospectors frequently mistake earthy chlorite for carbonate of copper. It is frequently found as a gangue mineral in ore deposits (see the Bora Creek silver ores in case 58). Emmaville, Lucknow, &c.

Jefferisite; Pennsylvania.

Pyrosmalite; a worm-like variety from Nordmark, Sweden.

Clinochlore; a mica-like variety from Pennsylvania and Russia.

Ripidolite; Pennsylvania.

Penninite; a pretty pink variety on serpentine, Dundas, Tasmania.

Delessite; a fibrous variety. 10012, Wentworth Extended Mine, Lucknow.

Canada, Wattle Flat.

Chloritoid.

Hydrous silicate of magnesia; a very soft mineral with a greasy feel; white to light-green in colour. Two varieties occur: foliated and massive. When of snowy-white colour and very pure the fibrous varieties have some commercial value, more particularly as a filling for wall-paper. The massive form, *steatite*, popularly known as soapstone, French chalk, &c., can

be readily shaped by cutting, and is used in a variety of ways. No deposits of commercial value are known in New South Wales. The best specimens of foliated talc from this State are from the Abercrombie District, and of fibrous talc from Gilmandyke, near Rockley.

Foliated talc from Mount Gipps, Euriowie, Cootamundra, Tumbarumba, and Abercrombie. *Steatite* from Abercrombie, Goulburn, Red Hill (Barrier Range), Wiseman's Creek.

Saponite. Hydrated silicate of alumina and manganese; Dumbarton (Scotland).

Pyrophyllite¹ Hydrated silicate of alumina; Gundagai.

Pilinite. Hydrated silicate of lime, alumina, and lithia; New Almaden quicksilver mine, California.

Glauconite. Hydrated silicate of alumina and potash; France. Also Sydney District (**case 31**).

Epidote. Silicate of alumina, lime, and iron. A yellowish-green mineral frequently mistaken for copper ore. It sometimes occurs as a secondary mineral in altered andesites and other lavas. It is sometimes associated with native copper, in small quantities.

Rockley, Emmaville, Pambula, Blayney, Bunnamagoo. A fine specimen from Blayney, associated with felspar, is in **case 147**.

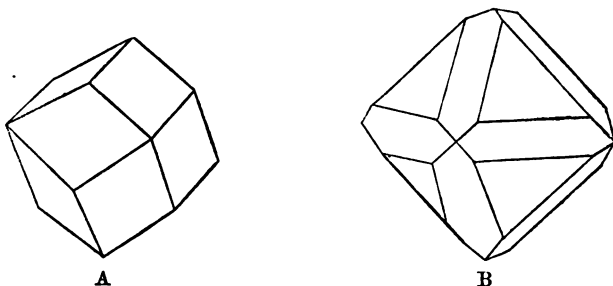
Thulite; manganese variety; Norway.

Pistacite; variety rich in iron; Russia.

Case 100. Under this heading is included a number of silicates differing from one another in containing lime, alumina, magnesia, or other oxides, but agreeing in crystal form, in hardness, and in specific gravity. The hardness is about the same as quartz, so that garnet cannot be scratched with a knife; the specific gravity varies a good deal, but is always greater than quartz; generally the weight is at once noticed when a specimen of fair size is lifted. The crystal form is very characteristic, consisting of the

Garnet.

rhombic dodecahedron, often modified by faces of *icositetrahedron*.
Very often, however, garnet occurs massive.



Garnet crystals.

A. *Rhombic dodecahedron*.

B. *Rhombic dodecahedron with icositetrahedron*.

Garnets are classified by means of their chemical composition into lime-alumina, iron-lime, and other groups, but the specimens from New South Wales have not yet been investigated to any extent. Many localities in New South Wales are represented.

9192, Broken Hill; pretty pink garnets in schist. In case 145 a larger specimen will be found.

5923, shows muscovite (mica) interpenetrating garnet.

7642, Gundagai; a massive form of lime-alumina garnet.

4041, Macleay River; a crystal (*rhombic dodecahedron*) with very sharp edges.

9500, Willi Willi, Macleay River.

6314, Broken Hill; in the sulphide ore.

7004, Broken Hill; a large crystal removed from within a mass of *galena*.

3746, Duckmaloi, near Oberon, with wollastonite. Both minerals are the result of contact-metamorphism (see page 147).

5818, Yarrangobilly; green variety.

5964, Yarrangobilly; a characteristic crystal.

5798, Turon; lime-alumina garnet.

9390, Beadle's Farm, Moonbi; small crystals in calcite.

10099, Ruby Hill, Bingera; *pyrope* (alumina-iron-garnet), included in basalt; a polished slice. Round the garnet, which takes a good polish, and is almost of gem quality, will be noticed a rim of alteration products, known as *kelyphite*.

Topazolite, a variety of iron-lime garnet; Canada.

Spessartite, manganese-alumina garnet; Virginia.

Grossularite, lime-alumina garnet; Russia, Maine.

Ouvarovite, lime-chrome garnet; Canada, Russia.

Johnstonotite, manganese-magnesia-iron-lime garnet, Tasmania.

3423, Mexico; a pretty rose-coloured garnet in limestone; polished.

In case 105, is a large slab of mica-schist, showing garnets, from the well-known locality, Fort Wrangel, in Alaska.

Tourmaline. A silicate of varying composition, always containing a considerable proportion of boracic acid. It is equal to or above quartz in hardness, usually jet black in colour, and occurs characteristically in granite as essentially three-sided elongated prisms,* or in bunches of radiating needles. Not uncommonly found in quartz. A mineral that causes a good deal of perplexity to miners unfamiliar with it.

Rubellite, pink tourmaline; Russia; California.

It has been found in considerable quantities at the Californian locality in a rock consisting of quartz and lithia-mica. A beautiful specimen of this will be found in 119.

Brown Tourmaline, California.

Zeuxite, a green variety from Mount Bischoff, Tasmania.

Schorl, black tourmaline, the common variety. This has been found in many of the granite areas of New South Wales. A few are selected for exhibition.

Cooma, Junee, Mount Gipps, Oban, Wyalong, Temora, Uralla, Glen Innes, County Selwyn, Broken Hill, Bendemeer, Barraba, Deepwater.

* A good crystal of tourmaline will be found in case 33.

3174, Wallangra; radial form in quartz. **237**, Cooma; elongated single crystals.

8746, Ballala, near Uralla; very distinct crystals in the rock, pegmatite.

7337, Oban; portion of a very large crystal.

6907, Glen Innes; portion of a large crystal, showing the end faces.

Silicate of alumina. Boulders have been found in Burra Creek, Andalusite. Tumbarumba.

Silicate of alumina; in characteristic cross-shaped twin crystals. A good specimen of staurolite in mica schist will be found among the Broken Hill rocks in **case 145**.

A variety of staurolite, containing foreign particles diagonally arranged. **10104** (polished), magnificent specimens from South Australia.

Silicate of alumina. Often of a beautiful blue colour. Cooma, Kyanite. Burra Creek (Tumbarumba). In Burra Creek it is found as pebbles. **10011**, Alma Mine, near Broken Hill; a blue variety in copper-bearing mica schist. For a large specimen, see **case 145**.

Staurolite, chiastolite, and cyanite are secondary minerals occurring in schists.

Russia. This mineral has recently been detected in a rock Cordierite, from Broken Hill.

A silicate of lime, &c., containing boracic acid. Colebrook Axinite. Mine (Tasmania), Namoi River.

Silicate of alumina with a good deal of fluorine (see page 18, Topaz. and gem-cases **78, 49**). Topaz is associated with tinstone in New England and Mount Bischoff (see pages **67, 114**.)

The variety at Mt. Bischoff is the radial one, known as *pycnite*.

5418, Mourne Mountains, Ireland; with *beryl* and *felspar* occupying cavities (*druses*) in granite.

9268, Dingo Creek, Torrington; a blue variety.

Beryl. Silicate of alumina and berylla (see **emerald**, page 19, and **gem-cases 78, 49**).

7929, Gulf Stream Tin Mine, New England.

5416, Wicklow, Ireland; in granite; also in **case 120**, from the same locality, associated with schorl.

7422, Maine; good crystals.*

Colemanite. Borate of lime (hydrous); California.

Danburite. Borate and silicate of lime; New York State.

Datolite. Borate and silicate of lime (hydrous); Colebrook, Tasmania.

Case 99. **OXIDES.** Oxide of aluminium (see **sapphire** and **ruby**, page 17, and **gem-cases 78, 49**; also **emery**, page 131, **case 91**).

6992, Russia; in matrix. Berrima. Victoria (variety *barklyite*).

Spinel. *Gahnite*, oxide of zinc, aluminium, magnesium.

8545, Sandy Creek, Tenterfield; colourless masses consisting of microscopic octahedral crystals. **9187**, Broken Hill, with galena.

Pleonaste, oxide of magnesium, iron and aluminium. This is a black spinel, frequently found in gem sands; in octahedral crystals when not too much water-worn. Wingecarribee River (Berrima), Brindabella.

GROUP V.

Case 99.

Sulphates.

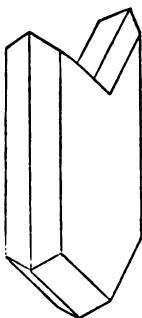
Epsomite. Hydrated sulphate of magnesia; a secondary mineral, with a beautiful acicular structure.

Anhydrite. Sulphate of lime; a blue variety from Bleiberg, Carinthia.

Gypsum. *Selenite*, hydrated sulphate of lime; the well-known mineral used in the preparation of plaster of Paris (see page 129, **case 106**). Characterised by its softness, being easily scratched with the thumb nail. It may occur earthy, massive, or crystalline.

* Crystals of enormous size have been found in some American localities.

Gypsum crystals are very characteristic.* **9427**, a pretty specimen from Talbragar; and **8016**, from Hinton, show these crystals. Also crystals from Gewrie.



Twin Crystal of Gypsum.
(See page 55; foot-note.)

A fibrous variety is exhibited from Jenolan and Thackaringa.

In the far west of New South Wales an earthy form of gypsum frequently occurs in the vicinity of extinct mud-springs; several examples of these from the Bourke district will be noticed.

750, Canada; a clear variety.

794, Suez Canal; very transparent.

Further specimens of gypsum will be found in **cases 103, 104, and 105**.

Sulphate of strontia. Bristol (Eng.), Canada, Sicily (with Celestite, native sulphur).

Nodules have been found in the Bourke District.

Sulphate of baryta; a very common mineral often mistaken Barytes, for scheelite on account of its great weight. It is used in the manufacture of paint (see **case 110**). Canada; Northumberland (Eng.)

1315, Alston Moor (Eng.), showing the characteristic tabular form of the crystals.

* A good crystal of gypsum will be found in **case 33**.

At Nutfield, Surrey (Eng.), a yellow form of barytes is found in the Fuller's earth deposits. A large crystallised specimen is shown in case 119.

10331, Leadville ; transparent purple variety.

Although of common occurrence in New South Wales, none of commercial value has yet been found.

GROUP VI.

Carbonates.

Case 101.

Carbonates.
Calcite.

Carbonate of lime : one of the most common gangue minerals found in lodes. It presents great variety of form and colour. The most useful practical test for calcite is the effervescence that results when a drop of weak acid (vinegar for instance) is placed upon it. Calcite can be easily scratched with a knife.

A very common form of calcite is the *rhombohedron* ; moreover, all calcite, irrespective of its crystalline form, breaks up into little rhombohedral when tapped with a hammer, by reason of its good rhombohedral cleavage (fig. A). The purest form of calcite is *Iceland spar*, which breaks up into perfect rhombodetra as clear as glass. Iceland spar is in great demand by optical instrument makers ; it is by no means of common occurrence, and is not known from New South Wales.

Rhombohedral forms will be noticed from Yarrangobilly, Bombala, and the Consols Mine, Broken Hill. Another common form is a six-sided (*hexagonal*) prism, sometimes terminated by a *rhombohedron*.* 9279 is a good illustration ; also 257, Lionsville ; 4170, Consols Mine, Broken Hill ; 258, Golden Crown Mine, Solferino.

A third common form is the *scalenohedron*, constituting *dog-tooth spar*. This is shown by 270, Derbyshire, and others. Like the prism, the scalenohedron is often terminated by the rhombohedron.

Twin Crystals. 7445, "Butterfly calcite," Furness (Eng.).

In 3806, Burragorang, the intimate twin structure has been revealed by weathering, a sort of natural etching.

* Good crystals of calcite will be found in case 33.

The variety known as *nail-head spar* may be described as consisting of flattened rhombohedral crystals. 1308, Weardale (Eng.), and 260, Wallsend Colliery, are illustrations.

Black Calcite: Millgrove and Willi Willi, Macleay River.

Satin Spar: fibrous calcite. 7747, Gunnedah, occurring as veins in basalt; polished.

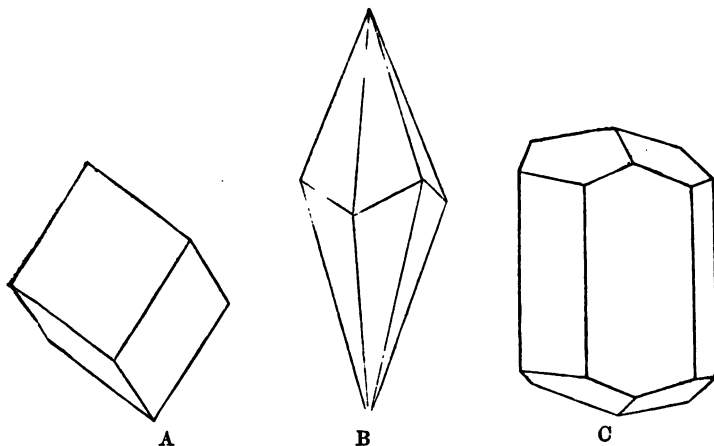
Ferro-calcite: carbonates of lime and iron, 9019, Boggabri; in basalt, 10151, Tullamore.

Fine specimens of calcite are exhibited from Frizington, Cumberland (Eng.), the Weardale Lead Mines (Eng.), and the Jenolan Caves.

3844, a curious botryoidal form, from Oregon.

A special exhibit of stalactites of carbonate of lime from the Limestone Caves is contained in case 134.

Larger specimens of calcite will be found in cases 125 and 121.



Crystals of Calcite.

A. Rhombohedron.

B. Scalenohedron.

C. Prism with rhombohedron.

Carbonate of lime. Aragonite differs from calcite in hardness, Aragonite. specific gravity, and system of crystallization. The best crystals

exhibited are from the Richmond basalt quarries, Melbourne, and from the Limestone Caves (see also case 43).

There are also forms that may be regarded as aragonite from Broken Hill, Murrumbidgee, and New England.

Strontianite. Carbonate of strontia. Scotland. Not known in New South Wales.

Witherite. Carbonate of baryta. Northumberland (Eng.), where it is mined. A beautiful crystallized specimen from here is exhibited in case 105. Not known in New South Wales.

Dolomite. Carbonate of lime and magnesia. Used as a source of salts of magnesia. Wellington, Gundagai.

A blue variety from Woodlands, Victoria, in Tasmania, and (case 128) in lode quartz, from the Mitchell's Creek Mine, will be noticed.

Case 102. Carbonate of magnesia. A dull white massive mineral used in the manufacture of Epsom salts. Commonly found as nodules. Harder and heavier than calcite, from which it and most other carbonates also differ in effervescing only in warm acid. Of commercial value when pure and in quantity, as it is in Asia Minor and elsewhere. Magnesite occurs in small quantities at many localities in New South Wales, either associated with serpentine, or in alluvial deposits or mineral lodes, but not in deposits of commercial value. Bingera, Tamworth, &c., &c.

Pistomesite. 6034, a variety containing carbonate of iron, Balhannah Mine, South Australia; it is auriferous and associated with bismuthite.

Case 102.

GROUP VII.

Fluorite.

Fluorides and Phosphates.

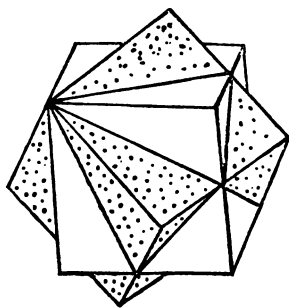
Fluoride of calcium: a not uncommon gangue mineral occurring abundantly in some mines. It can generally be recognised by means of the perfectly formed glassy cubes in which it is generally crystallized. The variety of colour displayed

by fluor-spar, as it is often called, is perhaps greater than in any other mineral; but shades of blue generally predominate. Small quantities are used for fluxing purposes in some smelting works. The Museum possesses a fine series of specimens from the lead mines of the North of England, where fluorite is very abundant and beautifully crystallized.

Fluorite has been found at a number of localities in this State; but the only good crystals are those from the Gundle Tin Mines, Macleay River. A block of the lode tin ore is exhibited in 126: it contains drusy cavities, lined with quartz and purple and green fluor.

6906, Shoalhaven; interpenetrating green and blue cubes. 285, Pheasant Creek, Co., Clive; banded, variegated fluor, with mica. 281, Deepwater; green. 9125, Deepwater; blue, with chlorite. 7760, Snowy River; blue. 7689, Young District; colourless. 7685, Red Range, Glen Innes; colourless. 59, Yass; colourless. 8239, Purnamoota, Barrier Range; blue, with galena. 2124, Emerald Mines, Emmaville; blue, associated with topaz, tinstone, and beryl. 8421, Bald Nob, Emmaville; greenish blue, with native copper.

In case 60, will be found fluor from near Yass, containing galena; and in case 63 azurite in fluor from the Good Hope Mine, Yass.



Interpenetrating cubes of fluor.

Wavellite.	Queensland, Lucknow, Cangi, Boro (?).
Turquoise.	See Gems (cases 49, 78, pages 19, 101).
Callainite.	Nevada.
Variscite.	Utah.

These are all hydrated phosphates of alumina.

Apatite.	Phosphate and chloride of lime. A valuable mineral when found in quantity (see case 91 and page 127). It is frequently found crystallised, the characteristic form being a six-sided prism and six-sided pyramid; it is sometimes terminated by flat ends. 744, Canada: typical crystals.* Apatite varies considerably in colour—green, brown, red. In addition to Canada, apatite is shown from Russia, Norway, and New York State. In this State it has been found at Gordonbrook only, where it occurs as a narrow vein in granite (see case 76, page 96).†
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Rock-Salt.	Chloride of sodium. Crystals—cubes—from Cheshire and Kansas. (For commercial rock-salt see case 108, page 135.) In case 108 will also be found a specimen from Peru, where it occurs as an efflorescence on the surface of the ground. In New South Wales it occasionally occurs in crevices of rocks, where it is protected from rain-waters; as an example of this a specimen from the Central Macdonald Ranges is exhibited.
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* A good crystal will be found in case 33.

† Apatite is very common as microscopic crystals in granite and many other igneous rocks.

METEORITES. †

The Earth in its orbit crosses the paths of swarms of stones that are also revolving round the Sun. When a portion of such a swarm comes within the sphere of the Earth's attraction, some of the stones are drawn out of their course, fall to the surface under the influence of gravitation, and are known as *Meteorites*. By friction with the earth's atmosphere such stones become incandescent, and are hence known as "shooting stars." No element has as yet been found in meteorites not already known as existing in the Earth's Crust. The most noteworthy point in their composition is the frequent presence of metallic iron alloyed with nickel. There is a complete gradation from meteorites composed almost entirely of metallic iron, and having a specific gravity of over 7, to stony varieties containing little or no iron, and consisting of such well-known minerals as *olivine*, *enstatite*, &c. These stony meteorites closely resemble some of the "ultra-basic" igneous rocks. Metallic iron has also been found in basalt. Meteorites are classified according to the relative proportions of the metallic and stony constituents.

The collection of meteorites will be found in a special case immediately opposite the entrance; while the Mungindi iron stands in a small case by itself in the central passage.

The series of specimens and polished slices of foreign meteorites is arranged after the classification of Dr. Brezina, and will be found on the upper shelves. This classification depends upon the character of the figures (*Widmanstätten*) which are produced when a polished surface of an iron meteorite is etched with acid.* A special slice, coloured to explain the terms used in describing these figures, will be found on the top shelf.

The New South Wales meteorites represented here are the Cowra, Bingera, Temora, Moonbi, and Mungindi. They are all iron varieties, and, with the exception of Bingera, belong to the *octahedral* division.

* The explanation of the production of these regular figures is that the meteoric irons contain different alloys of iron and nickel, which are arranged crystallographically and are attacked by acids with unequal intensity.

† The objects known as obsidian buttons are now regarded as of cosmic origin, and will in future be exhibited with the meteorites (see page 172).

The Bingera iron (pear-shaped) is of a very rare type, one from Mexico being the only known meteorite that resembles it. That from Cowra is also of an uncommon type, the Widmanstätten figures being of a much finer structure than the usual type (compare with the Bella Roca iron on the top shelf). The small fragment from near Temora is also almost unique; it is believed to have been broken off a large mass, which one would very much like to find. The two large irons found at Mungindi (Queensland side), early in 1897, weighed 52 lb. and 61 lb. respectively. The figures shown are very clear, while the meteorites themselves show the pitted surface, so characteristic of these bodies, extremely well.

The Mungindi Meteorites.—Early in 1897 these two large meteorites were found lying, one on top of the other, partly imbedded in the soil on the Queensland side of the New South Wales border, three miles north of the Mungindi Post Office (N.S.W.) When acquired they weighed about $60\frac{1}{2}$ lb. and $50\frac{1}{2}$ lb. respectively, but pieces had been detached previously. The composition is as follows:—

Iron...	...	...	90.307
Nickel	...	...	8.230
Cobalt	...	...	1.360
Phosphorus...	...	...	.093
Carbon	...	...	.010
Sulphur (traces)			

100.000

Specific gravity, 7.4.

Both meteorites are very hard to cut. Polished surfaces can be etched with weak acid with exceptional rapidity, and the resulting figures are beautifully clear, showing a distinct octahedral structure. Nodules of *troilite* (sulphide of iron) and small patches of *schreibersite* (phosphide of iron and nickel) are shown on the etched faces.

From the weathering they have undergone, it is evident that the "irons" had lain for a considerable time. In places the weathering has been sufficient to bring out the crystalline structure naturally.

LODE SPECIMENS.

It is intended to occupy two upright rectangular cases, facing the entrance with selected specimens illustrating the structure of lodes. A beginning has been made, but many of the specimens now exhibited will, it is hoped, soon be replaced by better ones.

Section of a Quartz Reef, Post Office Mine, Stuart Town; **Case 128.** a complete section across the reef, showing a "turn."

Section of a Quartz Reef, Mitchell's Creek, Wellington; banded quartz with *pyrite* and blue *dolomite*.

Silver Ore, Yerranderie Mine, Upper Burragorang; complete section across the lode showing the constituents in alternating bands.

Ore:—*Native silver, blende, mispickel.*

Gangue:—*Chalybite, quartz.*

Tin Ore, Saxony; *granite* traversed by irregular veins of *tinstone*.

Tin Ore, Carpet Snake Creek, New England; a portion of one of the pipes of tin ore—cylindrical areas of *granite*, impregnated with *tinstone*.

Copper Ore, Girilambone; chlorite-schist, along the separation planes of which the copper ore has been deposited.

Emerald Matrix, Emmaville; the emeralds occur principally in *claystone*, with *fluor, topaz, tinstone, &c.*, closely associated with *granite*.

Opal in Matrix, Whitecliffs; showing opalized wood and shells.

Diamond-bearing Wash, Bingera.

A series of specimens from Freiberg, Saxony, showing complete sections across various lodes; the parallel deposition of ore and gangue minerals is beautifully shown.

Silver ore, Rockvale, Armidale; siliceous *arsenical pyrites* traversed by veins of ruby silver ore (*pyrargyrite*).

Telluride Ore, Kalgoorlie; country rock with a thick vein of *calaverite* and other gold tellurides.

Asbestos, Canada; serpentine with a vein of asbestos, illustrating well the characteristic mode of occurrence of the mineral.

Wolfram, *scheelite*, *bismuth* and other ores are also shown here.

Case 136. *Gold Ores*, Baker's Creek, Hillgrove; siliceous slate breccia with *antimonite* and *free gold*. A large block of similar ore stands on an adjoining table.

Baker's Creek, Hillgrove; silicified slate-breccia, smoothed on one face to reveal the *free gold*.

Caledonian Mine, Yalwal; slate traversed by ferruginous veins showing *free gold* richly.

Mount Drysdale; a breccia of quartz and slate carrying *free gold*.

Bingera; serpentinous rock showing fine gold on the divisional faces.

Faulkner's Mine, Pambula; a rich shoot in felsite. A block specimen of Pambula stone occupies the end compartment of case 65.

Mandurama; the ore-body here is of a very remarkable nature. The specimen shows it interbedded with the claystones of the country; Adelong, Grenfell, Gilgunnia.

Silver Ore, White Rock, Drake; *quartz* with bands of argentiferous *galena*, *blende* and *pyrites*.

Mount Galena, Emmaville; cubical *galena* and *mispickel* with *quartz*.

Bismuth Ore, Jingera; granite traversed by veins of *native bismuth*, *molybdenite*.

Wolfram Ore, Tasmania; granite traversed by *wolfram* and *tourmaline* in veins.

Granite, Timbarra; traversed by a quartz vein. The rock on either side of the vein has been bleached by the mineralising agents.

BLOCK SPECIMENS OF ORE.

Auriferous Antimony Ore, Hillgrove.

Counter near
Entrance.

Lode Tin Ore, Butler's Mine, New England.

Lode Tin Ore, Cornwall.

"Banket," Johannesburg. The famous conglomerate of the Rand. The gold is contained in the cement, not in the pebbles.

Standing on the floor at the entrance are blocks of Boghead Mineral (Kerosene Shale) from Hartley, Joadja and Capertee.

In cases standing down the centre of the room or in end Special Cases compartments:

Chrome Iron Ore, Gundagai.

Auriferous Felsite, Pambula.

Stream Tin Cement, New England.

Cobaltiferous Wad, Port Macquarie.

Noumeaite, New Caledonia.

FINE MINERAL SPECIMENS OF LARGE SIZE.

Case 127. Picked specimens from Broken Hill, comprising *calamine*, *cerussite*, *stalactites*, *iodyrite*.

Molybdenite with crystallised *quartz* from the Kingsgate bismuth mines.

Case 126. *Crystallized tinstone*; New England.

Tourmaline and *tinstone* in pegmatite; Euriowie. These minerals are sometimes confused and the specimen is placed here to admit of comparison.

Case 125. Various Gold Ores, &c.

Pyrargyrite crystals in crystallised *arsenical pyrites*; Ruby Silver Mine, Armidale.

Calcite with *native arsenic*; Lunatic Reef, Solferino.

Calcite and *aragonite*; the Caves.

Calcite; Mudgee.

Case 46. Lead Ores.

Galena in octahedral crystals; White Rock Mine, Drake.

Pyromorphite; Mount Stewart Silver Mine (Plate III).

Cerussite; Tuena.

Anglesite, *pyromorphite* and *cerussite*; Broken Hill Copper Ores.

Case 43. Copper Ores from Mount Hope, Cobar, Broken Hill, Gundagai.

Small Case facing door. *Cubical pyrites* from Mount Stewart Silver Mine; one of the finest specimens ever found (Plate IV).

Antimonite, Japan. Very fine crystals of great size have been found in one mine in Japan; they are in great demand as specimens.

End Compartments. *Fluor*, well crystallised, in lode tin ore from Gundle, Port Macquarie.

Copper Ores, Wiseman's Creek and Macleay River.

PLATE VII.



COAL RENDERED PRISMATIC BY AN INTRUDING TONGUE OF IGNEOUS ROCK.

1. 1. 1.

2. 2. 2.

3. 3. 3.

4. 4. 4.

5. 5. 5.

6. 6. 6.

7. 7. 7.

8. 8. 8.

9. 9. 9.

10. 10. 10.

11. 11. 11.

12. 12. 12.

PLATE VIII.



GRANITE INTRUDING DIORITE, JUNESE.

GLACIAL GEOLOGY.

It has been clearly shown that in the Permo-Carboniferous **Case 110.** period of Palæozoic time, a large portion of what is now Central and Eastern Australia, was under the influence of *ice*. The evidence comes from every State of the Commonwealth as well as New South Wales.

It is well-known that in recent geological time, and indeed since the appearance of Man on the Earth, Northern Europe and America, including the whole of Great Britain north of the Thames, were in large part covered with moving ice, which descended from the mountains, occupied valleys, and to a large extent covered the plains. The evidence for this is briefly—

- a* The polishing and scratching of the rock-surfaces over which the ice moved—*Glaciation*.
- b* The formation of beds of clay containing a miscellaneous assortment of scratched pebbles derived from the rocks the ice has traversed—*Boulder Clay*.
- c* The presence of angular fragments of scratched rocks in position more or less removed from their parent rock—*Erratics*.
- d* Mounds of stone left behind by the ice as it retreated to higher levels when the climate became milder—*Moraines*.

At Hallett's Cove, near Adelaide, and elsewhere, polished rock surfaces have been found, and a specimen from this locality is exhibited here.

True boulder clay has been found in Central Australia, but not in this State.

Erratics have been found abundantly in what are known as the Upper Marine Beds, which underlie the Upper and Middle Coal Measures, and to a slight extent in the Lower Marine Beds which occur right at the base of the Permo-Carboniferous Series.


In the West Maitland District angular pieces of granite, quartzite, slate, Devonian grit, &c., frequently showing a smoothed

surface or a slight striation, are found in the Upper Marine Beds. Occasionally too, the beds immediately underlying such a block have been indented, showing that the block has been dropped from above. At Derrinal, Victoria, such an erratic of granite weighing 30 tons, and having its upper surface grooved and smooth, is embedded in mudstone. A picture of this will be found in this case. Similar evidence has been found in rocks of the same age in South Africa and in Southern India.

In South Australia there is evidence to show that a glacial epoch took place as far back as Cambrian times.

Glacial ice has existed in the Kosciusko Region in comparatively recent times. The evidence, which is very perfect, comprises glaciated surfaces, moraines, &c. A scratched boulder is exhibited here, and photographs will be found on the west wall.

Numbers of small erratics from this and the other States are exhibited together with some striated pebbles from America (Pleistocene Ice Age) and Switzerland (existing glaciers) for comparison.





SPECIMENS SHOWING CONTORTION.

STRUCTURAL GEOLOGY.

Specimens illustrating structural geology are contained in table cases 112, 113, and in pyramid cases 109, 111, 138.

WIND operates by means of driving sand: the sand itself becomes rounded much more perfectly than on a beach, while at the same time it polishes and otherwise wears away the surfaces of rocks and pebbles exposed to it. In the western districts of this State wind-polished pebbles are common (case 113). Atmospheric Agencies.

RUNNING WATER rolls along with it boulders, gravel, or sand, according to its force. These become rounded by rubbing against one another. Notice that the smoothing produced by water is not nearly so perfect as the polishing effect of wind-driven sand (case 113). Rounded boulders (case 109).

WEATHERING:—By weathering is meant the changes effected by rain-water soaking into the earth's crust. These changes are produced partly by means of the solvent action of the water, but principally through the action of the gases taken up by the water during its passage through the soil. Thus the numerous iron-stone and other gossans shown in the ore-cases have resulted from the decomposition of sulphides, such as pyrites, under the influence of surface waters.

9015, Sunny Corner Silver Mine. A honeycomb-like mass of silica. This was originally a mass of pyrites traversed by thin plates of quartz. The pyrites has been removed by weathering, leaving the siliceous portions intact.

In case 138 is a spheroidal mass of diorite from Tumbarumba, the shape having been produced by weathering. Certain igneous rocks show a great tendency to weather in this way.

DEPOSITION BY WATER:—*Stalactites* and *Stalagmites*. In percolating through the lime-stone rocks, water, by the aid of the carbonic acid it has absorbed from the soil—dissolves a certain quantity of carbonate of lime. After oozing through the roof of a cavern, drops of the water remain suspended for a

while, and a portion of the carbonate of lime they contain is deposited on the ceiling. In course of time this accumulates after the manner of icicles, giving rise to the pendant form known as *stalactites*. After hanging for some time the drops of the water have increased to such a size that eventually a portion drops to the floor, splashing out more or less. On the evaporation of this water, the remainder of the carbonate of lime is deposited. In this way massive columns, known as *stalagmites*, are built up.

In case 134 stalactites and stalagmites from some of the Limestone Caves of New South Wales are mounted in a natural position.

Similar stalactites of iron-pyrites, ironstone, and manganese wad are shown in case 113. Other specimens from the upper levels of the Broken Hill Mines are contained in case 127.

Travertine: A deposit of carbonate of lime, frequently produced by springs—the so-called “petrification.” It is commonly the case that pieces of stick, leaves, shells, or other objects become encased in these deposits. Nattai River (case 113), Manilla (case 111).

Sinter: A deposit of silica produced by hot springs. This differs from travertine principally in consisting of silica instead of carbonate of lime. New Zealand, Yellowstone Park (case 113).

Limonite: Hydrated brown oxide of iron is frequently deposited from water, giving rise to *bog-iron ore*.

In case 106 is a mass of stick, bark, and leaves, encrusted and cemented together by hydrated oxide of iron, from the base of a rock-fern, part of which was still growing, and part similarly encrusted. This highly interesting specimen is from Mount Victoria.

Concretions

Carbonate of lime, ironstone, and other substances have a tendency to aggregate together in rocks, giving rise to more or less spherical masses, often with a concentric banded formation; this is known as *concretionary structure*. Small specimens in case 113.

In **case 109** are several large specimens of concretionary ironstone from New South Wales. Also a concretionary mass of chert—an impure form of silica often found forming bands in sedimentary rocks—in which the original planes of bedding may still be traced.

In which rocks such as ironstone, bauxite, and limestone are made up of an aggregation of pea-shaped grains. Pisolitic Structure.

Pisolitic ironstone from Ph. Bumballa (Wingello District), in **case 109**.

Similar to pisolitic, but the component grains are much smaller. Oolitic limestones will be found among the sedimentary rocks. Oolitic structure.

The replacement of one mineral substance by another is of very common occurrence, the replacing substance being generally silica (*silicification*). **Case 113** contains a number of very interesting specimens of this (see page 142). Pseudo-morphism.

Coral replaced by *chalcedony*, also **case 111**.

Coral replaced by phosphate of lime (see page 123).

Limestone replaced by silica (*Beekite structure*).

Rhyolite replaced by *chalcedony* (see page 141).

Wood, fossil shells, and various minerals replaced by some form of silica.

Calcite replaced by *quartz*, which still shows the cleavage structure of the original mineral.

Chalybite replaced by *limonite*—a very common form of alteration.

Quartz-Porphyry, the base of which has been completely replaced by topaz.

Thinolite, a peculiar pseudomorph of carbonate of lime after some other mineral. Specimens from Jervis Bay, Singleton, and Mount Vincent.

Case 112, Lava; New Hebrides, Europe.

Volcanic rocks.

Bombs.—New Zealand (recent eruptions): France (eruptions of Tertiary age): Wollongong, in tuff of Permo-Carboniferous age (also in **case 111**).

All over Australia and in the East Indies scattered over the surface, or entombed in alluvial drifts, are found curious little button-shaped bombs of black volcanic glass. The origin of these is not understood, but it is now generally believed that they have come from some source beyond the Earth—in other words, they are glassy meteorites. Specimens are shown from Uralla, Braidwood, Cobar, Barrier Range, Central Australia, Victoria, and West Australia. Those from the alluvial leads at Uralla are beautifully preserved; they seem to have fallen into the water, and were then covered up by alluvial material which has protected them from damage.*

Alteration Effects.—The effect of a mass of molten rock coming in contact with sedimentary strata is to harden the latter, and sometimes to produce a columnar structure. In this way coal may be *coked*, sandstone may be converted into *quartzite*, and shale into *lydian stone* or *jasper*, and all three may be rendered prismatic. Similarly limestone becomes marble. Coked Coal is shown from Bulli, Mittagong, and India. The Mittagong specimen is also prismatic. At the end of case 63 is a most instructive specimen showing a tongue of igneous rock intruding coal: the coal is prismatic all round the tongue (Plate VII).

Columnar baked shale from East Maitland in case 138.

Columnar sandstone occurs near Sydney (see page 186).

Columnar jointing.—Igneous rocks on cooling very frequently assume a beautiful columnar structure. The columns may be scores of feet long and several feet in diameter. This is well shown in the photograph of the Kiama blue-metal quarries, on the north wall.

A column of basalt, that has been used as a landmark, has been mounted in case 131. Columnar porphyry from Cowra, 138.

Miscellaneous. Case 112.—*Foraminiferal Sands.*

Case 111—*Coal Nodule.*—The origin of these rounded masses of coal is not understood. In the English Coal Measures they frequently contain remains of fossil plants most beautifully preserved.

* It is much to be wished that miners and others would interest themselves in these objects, and make an exact note of the position in which they are found.

Flexible sandstone, India.—Flexible sandstones and limestones have been found in several parts of the world; they bend somewhat like a sheet of thick india-rubber.

Cone-in-cone structure.—A curious structure found in shale at Picton and elsewhere.

Ripple-marks.—The ripples made by the waves of the sea upon an ancient beach. A large slab from Pymont quarries is placed near the Sydney case. Ripple-marks are very common in the rocks round Sydney.

Geodes.—Hollow masses of chalcedony, &c., sometimes lined internally with crystals. Good specimens from Illinois.

Interbedding of volcanic tuff with claystone. Also the same tuff jumbled together with radiolarian chert.—Both from Tamworth.

Intrusion of volcanic agglomerate by igneous rock, Moonbi Range.—The fragmental character of the agglomerate is well brought out by the weathering it has undergone.

Intrusion of diorite by granite, Juneë.—A large slab showing well the intrusion of one igneous rock by another (Plate VIII).

Bone Breccia, Wellington Caves.—The accumulated remains of animals, frequently extinct, that have occupied the Caves.

Slickensides.—The walls and other portions of mineral lodes are often found polished and grooved, due to one surface having moved over another. Specimens of slickensided coal, galena, quartz, ironstone, pyrites, quartz-felsite, calcite, and flucaen will be found in cases 112, 113, and 133. In some of these a fine film of gold has been deposited over the slickensided surfaces at a later date.

Structures due to Movement of the Rock within the Earth's Crust

Distortion, shearing, crushing, case 112.—Pebbles from a conglomerate at Gundagai have been flattened and sheared (that is, one portion displaced relatively to the rest) by the intense pressure to which the rock has been subjected. From Barmen pebbles from a similar conglomerate have been not only distorted in this way, but have been pressed together with such force that one has been indented by the other. The best

specimen of a sheared pebble is, perhaps, that from the All Nations Mine, Drake, one portion of the pebble being displaced very considerably.

At Bushy Hill, Cooma, and many other places, quartz-porphyrries exist which have been converted into a slaty rock by intense crushing within the Earth's Crust. Specimens of crushed and uncrushed porphyry, together with a series of photographs showing the effect of crushing upon rocks, are exhibited in 112.

At Broken Hill great crushing has taken place. In this way the large crystals of garnets and quartz in schist have been drawn out somewhat, and remain as eyes, while the rest of the rock has flowed round them under the influence of the pressure.

Contortion.—Quartz-veins, clay-shale, &c., have been crumpled by lateral pressure. This is shown by specimens in cases 112, 113, 138 (Plate IX).

Cleavage, case 138.—A piece of Cambrian slate from South Australia shows a series of parallel cracks which have been produced by earth-strain. The cracks are filled in with calcite, and occur in certain bands only of the rock.

The meaning of *cleavage* is well illustrated by a piece of slate from South Australia. The original bedding-planes are indicated by differently-coloured bands. The rock, however, no longer splits along these surfaces, but along a new set of parting-planes, one of which constitutes the face of the specimen. This second set of parting-planes has been set up by the pressure to which the rock has been subjected since its consolidation.

Faulting.—Hand-specimens sometimes show on a small scale the displacement known to the miner as "faulting." In case 138 will be found sandstone, shale, limestone and clayslate that have been faulted. The polished marble from Fernbrook and a pebble of chert show a double fracture, producing a *trough-fault*. There is also a quartz-vein that has been faulted by two others.

Photographs. Photographs illustrating structural geology are hung on the north wall; others are mounted in an album facing the entrance.

ROCKS.

The collection of rocks is a very large one, but very little space is at present available for its exhibition. The small series now on view must, therefore, be regarded as temporary only. A separate guide to the igneous rocks of New South Wales will be issued shortly.

The division at present adopted is a three-fold one, viz., New South Wales, Inter-State, and Foreign.

The primary division is into *igneous* and *sedimentary*. The igneous rocks will then be grouped *geographically*. In this way those from the New England Table-land, or from the Hawkesbury Formation, will be found together. The igneous rocks from any given district will be arranged according to the table on page 177. The sedimentary rocks will be arranged according to their geological age (see page 178).

Barrier Range.—The rocks here constitute a complex group of igneous and sedimentary origin, of the greatest geological age, that have undergone intense metamorphism. They consist principally of gneisses and schists. Igneous Rocks
N. S. Wales.
Case 145.

8109 is a fine specimen of staurolite-mica-schist, and 10111a of cyanite-mica-schist.

Western District.—Trachytes, basalts, and tuffs from the Canoblas, Orange—an old volcanic centre. Cases
146, 147.

Northern District.—Crystalline acid rocks. Granites and porphyries from New England, &c. Case 142.

Northern District.—Hemi-crystalline, glassy, and tuff rocks. A rhyolite (an old lava flow) from Paddy's Hill, Raymond Terrace is exceptionally fine. Large blocks of it are placed on the top shelf of case 147. By means of these and of the large transparent slice shown here the visitor will readily distinguish the flow-structure produced when the rock was a stream of viscid lava. Very fine rhyolite glass occurs in the Tweed River, and in the Carboniferous Strata of the Copeland and other districts. Case 143.

Northern District.—Basic rocks.

8961, Elsmore; a magnificent specimen of basalt glass or *tachylyte*.—This rock occurs at the sides of a basalt dyke or sheet, where it has cooled quickly. It is not a common rock, and is usually a very thin edging only. A similar tachylyte occurs at Bowen Park, near Cudal. Case 144.

8957, Mullumbimby.—Basalt containing numerous crystals of very glassy labradorite felspar.

Case 143. Southern District.—Acid rocks. A block of nodular felsite from near Bega is placed on the top shelf of **case 145**. Auriferous rhyolites will be found among the Yalwal ores in gold **case 56**.

Case 142. Southern District.—Basic and intermediate rocks.

On the top shelf of **case 147**.—A large specimen of prehnite from the Permo-Carboniferous andesite at Dapto.

On the top shelf of **143**.—A block of basalt from Bulli containing masses of olivine and of hornblende.

**Sedimentary
Rocks.**

N. S. Wales.

Case 145. Palæozoic.—Slates, limestones, and quartzites.

Case 146. Cretaceous.—Sandstones and quartzites.

Case 147. Tertiary to Recent.—Including alluvial drifts.

**Intercolonial.
Queensland.**

Show-case 116a.—Country rocks of the Croydon and Gympie Gold-fields.

The porous sandstones and grits of Southern Queensland, of Lower Cretaceous and probably Ipswich Coal Measure age, which form the catchment area of the Artesian Water Basin, are exhibited in connection with the Artesian Water Case near the entrance (page 97).

**Tasmania.
South
Australia.**

Show-case 118a. The Tasmanian collection includes a number of unusual rock-types such as melilite-basalt, sölvbergite, &c.

New Zealand.

Show-case 118b, 117b.

**Norfolk
Island.
The Islands.
The Antarctic.**

Show-case 116b.—The Antarctic rocks were those first collected from Victoria Land.

8919, near Noumea, New Caledonia.—Limestone consisting of the remains of foraminifera, some of comparatively large size.

Foreign.

A type series of European igneous and sedimentary rocks from well-known localities.

**Cases
114, 115.**

Typical foreign sedimentary rocks.

**Cases
119-121.**

Typical foreign igneous rocks.

*Simple Classification of Felspar-bearing Igneous Rocks.**

		Free silica. ACID.	No free silica. INTERMEDIATE.	Poor in silica. BASIC.	
Minerals characteristically present.		Orthoclase Felspar.		Plagioclase Felspar.	
		Quartz.	No Quartz.	Hornblende. Pyroxene. Biotite.	Olivine.
Generally Lavas and Dyke rocks.	Glassy	Rhyolite Glass (Obsidian, &c.)	Trachyte Glass.	Andesite Glass.	Basalt Glass (Tachylyte).
	Incompletely Crystalline.	Rhyolite, Quartz-porphry.	Trachyte. Many Felsites.	Andesite.	Basalt.
	Completely Crystalline.	Granite.	Syenite.	Diorite.	Dolerite. Gabbro.
Generally Deep-seated rocks.					

Typical Localities in New South Wales.

Rhyolite Glass—Tweed River ; Bulladelah.

Rhyolite—Paddy's Hill (Raymond Terrace.)

Quartz-porphry—Burraborang, and many others.

Granite—New England Table-land.

Trachyte—Canoblas (Orange).

Andesite Glass—Clarence Town.

Andesite (Hornblende)—Carcoar.

Andesite (Augite)—Port Kembla.

Diorite—Cox River.

Basalt Glass—Inverell, Cudal.

Basalt—Canoblas, Sydney, and many others.

Dolerite—Sydney.

Gabbro—Nundle.

*The recent discovery in the Snowy River District, and near Lue, of igneous rocks characterised by the presence of nepheline, will necessitate an amplification of this table. A few ultra-basic rocks will also have to be arranged for.

*Classification of the Sedimentary Rocks of New South Wales.**

CAINOZOIC.	Post Tertiary	{ Recent. Auriferous soils, and alluvial deposits in the beds of existing rivers. Pleistocene. Alluvial leads containing gold, tin, and gemstones.	
	Tertiary ...	{ Pliocene. Alluvial leads, frequently covered by basalt, and containing gold, tin, and gemstones. Miocene. Quartzites with plant remains at Dalton, near Gunning. Eocene. Marine limestones and calcareous sandstones of the Lower Darling; plant beds of the New England District.	
MESOZOIC.	Cretaceous ...	{ Upper Cretaceous (Desert Sandstone). Contains precious opal deposits. Middle Cretaceous. Auriferous alluvial leads at Mount Brown. Lower Cretaceous (Rolling Downs Formation). Some of the beds are porous sandstones, and contain artesian water.	
	Jurassic ...	{ Talbragar fish-bearing shales.	
	Triassic ...	{ Hawkesbury series and their equivalents ... { Wianamatta shales (contain fire-clays). Hawkesbury sandstones (building stone). Narrabeen shales.	
		{ The Ipswich Coal Measures ... { Form the base of the artesian water basin. These measures contain thin coal seams, not at present worked in New South Wales.	
PALÆOZOIC.	Permo-Carboniferous.	{ Upper or Newcastle Coal Measures ... Dempsey Series ... Middle or Tomago Coal Measures ... Upper Marine Series Greta Coal Measures Lower Marine Series ... Rhacopteris Beds and associated Marine Beds. Gympie claystones (of Queensland) ... Upper Devonian ... Lower Devonian ... Upper Silurian ... Lower Silurian ...	
	Carboniferous ...	{ The productive coal seams of N.S.W. occur in these measures.	
	Devonian ...	{ All the metalliferous lodes and reefs occur in the Silurian, Devonian, and Carboniferous formations, or in such igneous rocks as granites, quartz-porphyrries, felsites, and diorites.	
	Silurian ...	{	
		{	

* From "The Mineral Resources of New South Wales," 1901.

STRATIGRAPHICAL SERIES.

Selected specimens from the very large collection of New South Wales fossils are arranged in the wall-cases round the building in stratigraphical order. The labelling of these is not yet complete. It is anticipated that a description of these fossils will be prepared by the Palæontologist.

The series begins with the Cambrian Formation in case 1, and continues in ascending order to recent times.

Case 1.—As no Cambrian strata are known to exist in this State, a few trilobites, &c., from Tasmania and South Australia are placed here.

Case 1.—Lower Silurian rocks are found in several districts in New South Wales. The fossils by which they were recognised consist principally of badly preserved trilobites and graptolites. Graptolites from Victoria, and from Co. Wellesley, the Tom-ingley Mine (Peak Hill), Mandurama, and elsewhere are exhibited.

Trilobites and graptolites are forms of animal life that became extinct in early geological ages. Trilobites were crustaceans, allied to the modern king-crab. Graptolites were lowly organisms, a number of which formed a sort of colony by budding off from a central axis. Both existed in great number and variety in early Palæozoic times.

Cases 2-7.—Numerous corals—particularly *Favosites* and *Heliolites*—and trilobites from the Yass district.

In case 6 is a black marble from Walli containing the brachiopoda, *Pentamerus Knightii*. A larger slab of this will be found on the south wall.

In case 7, *Orthoceras* from Yass.

Orthoceras is an extinct chambered shell, resembling the nautilus, but straight, not coiled. It grew to a great size, and was fairly abundant in Palæozoic times.

Cases 10-14.—Many fine corals from Tamworth.

At Tamworth and elsewhere there are vast thicknesses of rocks, more or less made up of the microscopic remains of radiolaria.

Carboniferous. Cases 15-17.—Corals and numerous brachiopods, especially a “a winged” form—*Spirifer* and *Productus*. The extinct plants *Lepidodendron* and *Rhacopteris* are characteristic.

Lepidodendron is allied to the little club-mosses of the present day, but grew to a much greater height.

Permo-Carboniferous. Cases 18-27.—This is the formation in which the coal beds of New South Wales occur. The variety of animal and plant life is very great; and in some places the beds are crowded with fossils.

Case 18.—Plants, such as the ancient fern *Glossopteris*.

Case 19.—A curious coral—stenopora; magnificent fossil star-fishes from Farley; sea-lilies (*Crinoids*) from Nowra.

Case 20, 21.—Many varieties of the brachiopods *Martiniopsis* and *Spirifer*.

Cases 22, 23, 24.—Gigantic bivalve shells.

Case 25.—*Orthoceras*.

Cases 26, 27.—Plants.

Trias-Jura. Rocks of this age constitute the Sydney district and the Blue Mountains (see page 176).

Case 28.—Plants from Mount Victoria and Sydney.

Case 29.—A little crustacean (*Estheria*) found at a depth in the Cremorne bore and Balmain shafts.

Small freshwater shells (*Unio*).

In a quarry at Gosford great numbers (and variety) of fish have been found. These differ from modern fish in having an external armour of strong scales in place of an internal bony skeleton.* These will be found in cases 40, 41, and 42.

This formation was deposited in the estuary of a big river.

Cases 29, 39.—At Talbragar (Gulgong) beds of approximately similar age occur, containing the plants exhibited here and the fish in case 39. It will be readily seen that the fish differ from those found at Gosford, and resemble living forms in having a complete bony skeleton.

* Fish armoured in this way are known as *ganoids*.

Fossils of this age are not common in New South Wales. A Cretaceous. few opalised shells, belemnites, &c., will be found in case 48.

For comparison, *Ammonites* from India, casts of portions of the gigantic extinct reptile, *Ichthyosaurus* from Queensland, and other Cretaceous and Jurassic fossils, have been placed in case 38.

Cases 36, 37.—Bones of marsupials—some extinct—from the Tertiary, Pleistocene, and Recent. Limestone Caves.

Case 35.—Leaves and fruits from the deep leads.

Cases 47, 130.—Remains of the extinct *Diprotodon* and *Nototherium*. These animals were allied to the kangaroo and the wombat, but were of gigantic size; the former rivalling in this respect the rhinoceros, the latter the horse. The skull of diprotodon reached three feet in length. In case 130 some of these remains have been mounted in a natural position.

Case 37.—The extinct gigantic horned turtle (*meiolania*) of Lord Howe Island.

Cases 44 and 45 contain large specimens of various fossils.

GEOLOGY OF SYDNEY.

Two show-cases have been set apart on the southern wall to illustrate the geology of the Sydney District.

The rocks between Lake Macquarie and Clifton, and between Sydney and the Blue Mountains, consist of shales and sandstones, dipping slightly so as to form a sort of basin beneath Sydney, and intruded in many places by dykes of igneous rock. These rocks contain a few fossils which prove them to be of Triassic age—that is, they *overlie* the Coal Measures, and all the Palæozoic strata and older rocks to which valuable metals are generally confined. Could a deep bore be put down at Sydney, after passing through the Coal Measures, which have already been proved to exist, the older Devonian and Silurian rocks would be found. This order of strata will be better understood on reference to the table on page 173.

Sedimentary
Rocks.

The beds coming to the surface near Sydney are in descending order:—

Wianamatta Shales.

Hawkesbury Sandstones.

Narrabeen Beds.

Wianamatta Shales.—These constitute the fruit-growing soils of Hornsby, Parramatta, and Liverpool. They are used for brick- and pottery-making at St. Peter's and elsewhere; occasionally, too, they contain fireclays. They are frequently micaceous. The junction between the Wianamatta shales and the underlying sandstone may be seen in railway cuttings in the northern suburbs—near Carlingford, for instance. The junction is an irregular one, the surface of the sandstone evidently having been very uneven when the shales were laid down, as mud, on top of them.

Hawkesbury Sandstone.—A sterile sandstone, friable when first exposed, often forming a magnificent building stone, for which purpose numerous quarries have been opened at Sydney. When cut through by running water, it forms the magnificent headlands and precipitous cliffs and escarpments so

well known on the Coast, in the Blue Mountains and elsewhere. It is sometimes very pebbly and becomes a conglomerate. The rolled quartz grains have generally received a fresh supply of silica since the consolidation of the rock, and now exhibit more or less crystal form. It is the reflection of light by these crystal faces that occasions the glistening appearance of the sand on the roads about Sydney. It sometimes contains flakes of graphite. Small garnets also occur.

Narrabeen Beds.—Shales, sandstones, and conglomerates exposed to some extent in the cliffs between Narrabeen and Lake Macquarie, but known best in the various bores that have been put down through it, and in the shaft at the Balmain Colliery. The conglomerates are sometimes very pretty, through containing coloured jasperoid pebbles. In places the beds become copper-bearing (assays up to two per cent. have been obtained). Beds of volcanic tuff and heavy sand containing *zircon* and *magnetite* also occur.

Cores from some of the bores that have been put down stand **Igneous Rock** in the corner to the right of the entrance.

These consist of narrow dykes usually of olivine basalt, containing *analcite* in some cases, frequently occupying joint-fissures that cut across the sedimentary strata, and sometimes sending off small lateral offshoots. These dykes are more easily decomposed than the sandstone, in consequence of which their presence is indicated by white clay, or by a ravine with precipitous sides. At Long Reef, Narrabeen, an amygdaloidal dyke of diabase may be seen on the coast at low tide, standing up as a low wall. The occurrence of these dykes is best illustrated at Bondi, where ravines partly occupied by clay, and a boss of undecomposed basalt, occur. These dykes have injured the coal-seams, as was proved by the first bore put down at Cremorne. In addition to these dykes, more or less circular orifices (pipes), filled with basalt, or with volcanic breccia, occur. As an example of the first may be mentioned the blue-metal quarry at Dundas; of the second, the Valley at Springwood, the Basin, near Penrith, and Old Man Valley, near Hornsby Station.

These igneous rocks have altered the surrounding sedimentary strata; sandstones are baked into *quartzite*, shales into *lydian stone*, and either may be brecciated, as at Bondi and Dundas.

The white clay resulting from the decomposition of the igneous rocks can be sometimes used as kaolin. In a case of this character at Gosford the iron from the dyke has concentrated upwards, and has formed a capping of good *limonite*.

Specimens to be found near Sydney :—

Minerals.

In the Sandstones—

Barytes, very rarely.

Carbonate of lime, in coatings.

Coal, in small seams, in many places.

Felspar, decomposed. *

Garnets, very small and scarce.

Gold, very rarely seen as free gold.

Graphite, in small scales.

Jasper, pebbles.

Mica, in small scales.

Pyrites.

Quartz, frequently showing some traces of crystal faces.

In the Shales—

Calcite, *Chert*, *Ironstone*, *Glauconite* (Balmain shaft), *Mica*, *Native Copper*, and Carbonate of copper staining, have been found on fossil-wood in a tuffaceous bed of the Narrabeen Series, at Long Reef.

Magnetite, as grains in a tuffaceous bed at Long Reef.

Pyrites.

Zircon in sand at Long Reef.

Vanadium-staining in certain clays.*

In the Igneous Rocks.

As primary constituents—

Analcite.

* On weathering, these clays may show a green colouration. Buildings built of bricks made from them have had to be washed with acid to remove the stain thus produced.

Chrome diallage—Dundas.

Chromite—Dundas.

Olivine.

As alteration products, or secondary minerals:—

Analcite—Prospect.

Barytes—Coating joint planes at Dundas.

Calcite—*e.g.*, Dundas, where it encloses *quartz*, or may perhaps be replaced pseudomorphously by that mineral.

Chrome-staining—*e.g.*, at Bondi.

Common Salt—*e.g.*, Dundas.

Epsomite—*e.g.*, Bondi.

Kaolin—decomposition product.

Prehnite—Prospect.

Quartz—*e.g.*, Dundas.

Vivianite—Prospect.

Zeolites—*e.g.*, *Prehnite*, *Analcite*, Prospect.

These are very scarce.

Fossils

Plants.—Fragmentary plant remains, in particular the fossil fern *Thinnfeldia* may be found in many of the patches of shale throughout the Series. Good specimens are sometimes found. *Stems* occur in the tuffaceous beds at the top of the Narrabeen Series at Long Reef.

Crustacea.—The minute *Estheria* abounds in certain beds of the Narrabeen Series which only can be reached by bores.

Mollusca.—A very few specimens of *Unio*, a bivalve shell living in brackish water. They have been found at Bowral, Camperdown, and Pymble. Other mollusca have been found at Cockatoo Island and Narrabeen.

Fish.—Abundant fish remains were found in the ballast quarry at Gosford, and they are also found from time to time in the clay pits at St. Peters. They belong to a class that is now almost extinct, having an external scaly armour instead of an internal bony skeleton like modern fish. (See page 180.)

Reptiles.—Extinct reptiles, known as *Labyrinthodonts* by reason of the intricate structure of the teeth, are occasionally found. Specimens of these fossils will be found in the Stratigraphical Series. The fossil evidence shows that these strata were laid down on the estuary of a large river.

Structures

Columnar Sandstone is the most interesting structural peculiarity to be seen round Sydney. It has been noticed at quite a number of localities, of which Bondi is the best known. The Bondi quarry has now been partially reserved, but much of it has been destroyed. Columns will also be found in cases 131 and 138. Sometimes they are long and slender, at others short and thick; most commonly they are five-sided. The cause of this structure is not yet understood. At Bondi, igneous dykes are associated with it, and these are generally stated to have been the direct cause; nevertheless, elsewhere, for instance, near Pymble, no igneous rock can be found. The true explanation has yet to be found. A similar occurrence is known in the Inner Hebrides, Scotland.

Photographs of Columnar Sandstone at Bondi and Lane Cove River (Pymble) are on view.

Ripple-marks.—That the Hawkesbury Series were laid down in shallow water is evident from the abundance of ripple-marked slabs of shale and sandstone. A large slab of such sandstone stands near the door, and a similar piece of shale from the Balmain Pit hangs over these cases.

False Bedding.—This is another evidence of shallow-water conditions. It cannot well be illustrated by museum specimens, but photographs are on view.

Rocks.

Aluminous Ironstone, Quarantine Ground.

Basalt.—Many dykes.

Breccia (shale shattered by volcanic action).

Conglomerate.

Altered Dolerite (diabase).—Prospect, Narrabeen.

Gabbro.—Boulders included in the basalt at Dundas; also a dyke at the Basin, Nepean River.

Granite.—Boulders in the Nepean River.

Ironstone.

Lydian Stone (shale indurated by contact with a dyke of igneous rock).

Peat.—On the coast, near Manly.

Porphyry.—Boulders in the Nepean River.

Quartzite (sandstone indurated by contact with a dyke of igneous rock).

Sandstone (crystalline, micaceous, felspathic, graphitic, and ferruginous varieties).

Shale (laminated, micaceous, sandy, carbonaceous).

Volcanic Agglomerate.—Hornsby.

SPECIAL CASES.

Casts of Gold Nuggets. A number of the large Victorian nuggets. These include the famous Welcome Stranger, from Moliagul, near Dunolly, which weighed 210 lb., and yielded 191 lb. of gold, valued at £9,534.

From New South Wales are the following:—

Maitland Bar Nugget, Hargraves. This weighed 345 oz, and is valued at £1,236. The original is in the possession of the New South Wales Government.

Canadian Lead, Gulgong: 6½ oz.

Cadia, Orange: 21 oz.

Jews' Creek, Sofala: 8¾ oz.

Metallurgy. Copper smelting at the Great Cobar Mine: crude ores, intermediate products, and refined copper.

Case 122. Treatment of copper ores in Spain, including the production of sulphur.

Cleveland Iron Industry, Yorkshire: ores, fluxes, fuel, &c.

Tin-smelting at Sydney: artificial crystals of sulphide of tin.

Treatment of antimony ores.

Case 123. Samples of pig iron from England, America, and New South Wales (Fitzroy Works, Mittagong).

Nickel ore and matte, Sudbury, Canada.

APPENDIX A.

FOSSILS CHARACTERISTIC OF THE GEOLOGICAL FORMATIONS OF NEW
SOUTH WALES.

Students' Case 34.

Not yet identified in New South Wales.

Cambrian.

The trilobite *Conocephalites* from Tasmania.

Graptolites: *Phyllograptus*, *Didymograptus*, *Tetragraptus*, *Monograptus*. Lower Silurian.

Graptolite-bearing beds of Lower Silurian age have been found at several localities in New South Wales, but Victorian specimens are exhibited on account of their better preservation.

Corals: *Pholidophyllum*, *Heliophyllum*, *Favosites*, *Halysites*, *Heliolites*, *Rhizophyllum*, *Syringopora*, *Cyathophyllum*, *Mucophyllum*, *Receptaculites*. Upper Silurian.

Brachiopods: *Atrypa reticularis*, *Rhynchonella Wilsoni*, *Pentamerus linguifer*, *Pentamerus Knightii*, *Lingula*, *Spirifera*, *Strophomena*.

Trilobites: *Calymene*, *Sphærezochus*, *Phacops*, *Cromus*, *Bronteus*, *Acidaspis*.

Cephalopod: *Orthoceras*.

Gasteropods: *Murchisonia*, *Holopea*, *Omphalotrochus*.

Corals: *Sanidophyllum Davidis*, *Syringopora*, *Actinocystis*, *Litophyllum*, *Devonian*. *Diphyphyllum*.

Brachiopods: *Strophomena*, *Rhynchonella pleurodon*, *Spirifer disjuncta*.

Bivalves: *Pterinopecten*, *Pteronites*.

Plants: *Lepidodendron australe*.

Brachiopods: *Strophomena analoga*, *Productus semireticulatus*, *Spirifera Carboniferous*. *striata*, *Orthis resupinata*, *Orthis australis*, *Orthotetes cremistria*.

Plants: *Lepidodendron*, *Rhacopteris*.

Gastropods: *Euomphalus*, *Loxonema*, *Gosseletina*.

Brachiopods: *Martiniopsis oviformis*, *Martiniopsis subradiata*, *Spirifer Permo-Carboniferous*. *tasmaniensis*, *Productus brachythærus*, *Dielasma sacculus*.

Bivalves: *Pleurophorus*, *Mæonia carinata*, *Aviculo-pecten Fittoni*, *Eurydesma cordata*, *Aphanaia*, *Chænomya*, *Edmondia nobilissima*.

Gastropods: *Platyschisma*.

Cephalopods: *Goniatites*, *Orthoceras*.

Corals: *Zaphrentis*, *Stenopora crinita*, *Trachypora Wilkinsoni*.

Plants: *Phyllothea*, *Vertebraria*, *Glossopteri*.

Polyzoa: *Fenestella*, *Protoretetpora*.

Crinoids: *Cyathocrinus*, *Tribrachyocrinus*.

APPENDIX B.

DESCRIPTIVE LABELS USED IN STUDENTS' MINERALOGICAL CASE 33.

Fracture.

The nature of the surface produced by fracturing a mineral is a useful character. It is best observed in minerals that have little or no cleavage ; indeed, when cleavage is well developed it is very difficult to produce a true fracture at all.

The "Fracture" of a mineral is described as follows :—

1. Conchoidal—When the surface produced is curved : *quartz*.
2. Even—When the surface produced is nearly flat : *magnesite*.
3. Uneven—When the surface produced is rough : *copper-pyrites*.
4. Splintery—When the surface produced is splintery : *fibrous hematite*.
5. Hackly—A jagged surface produced : *native copper*.
6. Earthy : *chalk*.

Pseudomorphism.

One mineral is frequently found apparently crystallising with the form of another. This is always the result of some form of secondary action. Thus one mineral may

1. Be coated by another ;
2. Be dissolved away, and the resulting cavity subsequently occupied by another ;
3. Be gradually replaced, molecule by molecule, by another.

Various Optical Phenomena.

Lustre :—

Metallic : *galena, pyrites*.

Sub-metallic : *chrome iron*.

Adamantine : *blende, zircon*.

Resinous : *apatite, chloro-bromide of silver*.

Vitreous : *quartz*.

Pearly : *talc, selenite (one face only)*.

Silky : *asbestos*.

Play of colours : *precious opal*.

Change of colours : *labradorite*.

Opalescence : *moonstone*.

Iridescence : *limonite*.

Tarnish : "*peacock copper*."

Double refraction : *calcite*.

Hardness.

The "hardness" of minerals is very variable, and is of great value in their determination. It is tested by the readiness with which the mineral under examination can be scratched by other substances.

A series of ten minerals have been chosen as types, and arranged in the order of their hardness. These minerals are:—1. Talc. 2. Selenite. 3. Calcite. 4. Fluor. 5. Apatite. 6. Orthoclase. 7. Quartz. 8. Topaz. 9. Corundum (sapphire, ruby). 10. Diamond.

Each mineral in this "scale of hardness" will scratch all that precede, and can be scratched by all that follow it. By testing an unknown mineral with the different members of the scale, its place in the series can be readily determined. Thus, a piece of *galena* will scratch *selenite* (No. 2), and can be easily scratched by *calcite* (No. 3); in this case we should describe the hardness as between 2 and 3. As another instance, the *sapphire* and the *ruby* have a hardness of 9; unless the mineral will scratch *topaz* (No. 8), it cannot be *sapphire* nor *ruby*.

The following rough tests will be found very useful:—

1. A good knife or file will scratch all minerals that have a hardness of 6 or less.
2. A bronze coin can be scratched by all minerals having a hardness above 3·5.
3. The thumb-nail scratches all minerals having a hardness of 2·5 or less.

Tenacity.

Minerals behave very differently when cut or pulverised.

The following are the terms used:—

1. Malleability (when pieces can be flattened by hammering): *copper, gold, platinum*.
2. Sectility (when the mineral can be cut): *copper pyrites, copper-glance, silver chloride*.
3. Flexibility (when a flake can be bent without breaking): *talc, selenite*.
4. Elasticity (when the flake resumes its original position after bending): *mica*.
5. Brittleness: most minerals, *e.g., iron pyrites*.

Gold and *platinum* are found characteristically flattened in alluvial drift.

Elasticity is a very characteristic property of *mica*.

Cleavage.

Many minerals, when tapped with a hammer, show a tendency to separate into fragments having a certain definite form or into plates with parallel surfaces. This property is known as "cleavage," and is sometimes useful. It is generally best determined by placing the edge of a knife-blade upon the mineral in the direction in which it is expected to cleave and tapping it with a hammer. Frequently naturally-produced cleavages can be detected.

The direction of cleavage is dependent upon the form in which the mineral crystallises. For example: *fluor* crystallises in the cubic system, and its cleavages are parallel to the faces of the octahedron, this being the fundamental form of that system.

"Cleavage" may be described as:—

1. Highly perfect : *mica, selenite.*
2. Perfect : *fluor.*
3. Imperfect : *garnet.*
4. Very imperfect : *quartz.*

When the cleavage is imperfect the planes of separation will be more or less irregular.

The following are the principal instances of characteristic cleavages:—

Cubical : *galena.*

Octahedral :

Octahedron : *fluor.*

Tetrahedron : *fluor.*

Prismatic : *hornblende.*

Basal : *mica, topaz, sapphire, beryl, chlorite.*

Pinacoidal : *selenite, orthoclase.*

Domatic : *barytes.*

Rhombohedral : *calcite.*

Two cleavages : *orthoclase, barytes.*

NOTE.—The terms applied to the cleavages are derived from the crystallographic faces to which they are parallel. It is not necessary to understand these terms in order to make use of this method of mineral determination ; it is quite sufficient to become familiar with the appearance of the forms.

The forms assumed by minerals on crystallising are frequently of use in their determination. A number of common minerals which thus assume characteristic forms are arranged in the cases. The descriptions have been printed with inks of different colours, with a view to making a distinction between the information suited to those visitors who have already acquired some knowledge of crystallography and those who have not. The

particulars in red will be found useful to prospectors, as the minerals to which they refer may often be recognised by their external form. A crystallographic description is appended for the use of students.

Streak.

The colour of the powder of a mineral is one of the most useful aids to its determination. This colour is best seen by drawing the mineral over a piece of unglazed porcelain; but it is quite sufficient to observe the colour produced when the powder scratched or rubbed from the mineral is rubbed on paper.

A number of minerals are exhibited, the streak in each case accompanying the mineral of which it is characteristic. It will be noticed that the colour of the mineral is often very different from that of its powder, a coloured mineral frequently giving an almost colourless streak. Two or three examples of particular importance are as follows:—

No matter how the various forms of hematite may differ from one another in appearance, the streak remains the same—viz., blood-red. Cinnabar, which is so commonly confounded with hematite, gives a scarlet streak. Blende may be quite black, but its streak is never more than pale brown. The pale streak of tinstone should prevent any possibility of mistaking wolfram or limenite, which have red-brown and black streaks respectively for it.

Illustrations of characteristic streaks:—

- Hematite : *blood-red.*
- Cinnabar : *scarlet.*
- Limonite : *yellow-brown.*
- Göthite : *brownish yellow.*
- Gold : *yellow.*
- Wolfram : *dark reddish-brown.*
- Graphite (plumbago) : *black.*
- Ilmenite : *black to brown.*
- Molybdenite : *greenish black.*
- Copper pyrites : *greenish black.*
- Iron pyrites : *greenish or brownish black.*
- Mispickel (arsenical pyrites) : *dark grey.*
- Antimonite : *lead-grey.*
- Galena : *same colour as the mineral.*
- Bismuth : *silvery, with tinge of pink.*
- Blende : *colourless to buff.*
- Chalybite : *colourless to buff.*
- Tinstone : *white or pale-grey to brownish.*

Form.

The inconceivably minute particles—molecules—of which minerals are made up are arranged symmetrically, or may be aggregated together without following any definite plan. In the first case, the minerals are said to be “crystalline,” and have a tendency to occur in definite geometrical forms—crystals. Some of these forms will be exhibited elsewhere. In the second case there is no such tendency.

In this place are illustrated some of the characteristic forms assumed by minerals when non-crystalline, or when, although crystalline, no definite form is evident.

Illustrations of characteristic forms :—

Dendritic or arborescent : *manganese oxide*.

Tabular : *specular iron*.

Platy or leafy : *native copper*.

Wiry : *native silver*.

Mossy : *native copper*.

Capillary (hair-like) : *millerite*.

Coralloidal : *aragonite*.

Stalactitic : *calcite*.

Mammillated : *malachite*.

Botryoidal (like a bunch of grapes) : *manganese oxide*.

Reniform (kidney-shaped) : *hematite*.

Granular : *galena*, *magnetite*.

Acicular (needle-like) : *antimonite*.

Fibrous : *gypsum*, *asbestos*.

Radiated : *natrolite*.

Micaceous : *hematite*.

Foliated : *molybdenite*.

Nodular : *marcasite*.

Amygdaloidal : *aragonite*.

Geode : *quartz*.

Matted (reticulated or interlaced) : *chalcotrichite*.

Amorphous : *wad*.

APPENDIX C.

GLOSSARY.

- Arborescent*.—Plant-like in form.
- Alluvial*.—Clay, sand, and gravel deposited by running water.
- Anhydrous*.—A term applied to minerals into whose composition water does not enter.
- Argentiferous*.—Containing silver.
- Auriferous*.—Containing gold.
- Botryoidal*.—Resembling a bunch of grapes in form.
- Breccia*.—A rock composed of angular fragments cemented together.
- Calcareous*.—Containing lime.
- Carbonaceous*.—Containing carbon.
- Cement*.—Gravel or sand cemented together into a coherent mass.
- Cleavage* (of minerals).—The property possessed by many minerals of splitting into flakes with parallel faces.
- Cleavage* (of rocks).—See page 174.
- Concretionary*.—The formation of rounded masses of various substances subsequent to the consolidation of the rocks containing them.
- Conglomerate*.—A rock composed of pebbles cemented together.
- Crushing* (of rocks).—This refers to the fracturing and distortion of rock masses under the intense pressure caused by movements of the Crust of the Earth.
- Dendritic*.—Moss : or fern-like in form.
- Denudation*.—The destruction of rocks by water, waves, &c.
- Diabase*.—A dolerite or other allied rock in which secondary minerals such as chlorite have arisen from alteration.
- Druse*.—A cavity lined with small crystals.
- Dyke*.—A wall-like mass of igneous rock cutting across other rocks.
- Faulting*.—See page .
- Felspathic*.—Containing felspar or its decomposition products.
- Flux*.—Any material which forms a fusible compound (slag) with the gangue of an ore that is being smelted.
- Gangue*.—Those constituents of a mineral lode that have no direct commercial value.
- Gem-sand*.—A general term for coarse or fine sand consisting largely of zircon, spinel, garnet, &c.
- Gossan*.—The spongy ferruginous material frequently found capping a mineral lode.

Hemi-crystalline.—Applied to an igneous rock which consists partly of non-crystalline material.

Holo-crystalline.—Applied to an igneous rock which is composed entirely of definitely crystalline minerals.

Igneous Rocks.—Those formed by the fusion of pre-existing rocks.

Impregnation.—A term applied when secondary minerals are disseminated through the mass of a rock.

Lava.—Rock that has flowed from a volcano at the surface of the earth.

Lead.—See page 27.

Malleability.—The property possessed by some minerals of flattening without crushing when hammered.

Massive.—Applied to minerals which, while being truly crystalline in structure, do not show any external crystal form.

Melaphyre.—Basalt that has been highly altered with the production of secondary minerals.

Metamorphism.—The operation of agencies such as pressure, whereby rock masses entirely lose their original characteristics.

Octahedron.—A crystal form, consisting of a double four-faced square pyramid, the edges of which are all equal in length. See page 74.

Oolitic.—A structure in rocks, occurring particularly in limestones, whereby they resemble the roe of a fish.

Pegmatite.—A coarsely crystalline rock, consisting essentially of quartz and felspar, frequently found in veins traversing granite.

Pisolitic.—Similar to oolitic, but coarser, the granules approximating to peas in size.

Porphyritic.—Applied to an igneous rock contains crystals of conspicuously large size.

Pseudomorphism.—The replacement of one mineral substance by another.

Pyrite.—The usual abbreviation for iron pyrites.

Rhombic dodecahedron.—See page 151.

Ruby Silver.—Applied to certain silver ores, consisting of silver combined with sulphur and antimony or arsenic, that have a ruby appearance.

Saccharoidal.—Sugary in appearance.

Schistose.—Slaty in structure.

Secondary.—Applied to minerals and structures developed in rocks subsequent to their formation.

Sectility.—A property possessed by certain minerals whereby they may be cut with a knife.

Shearing.—The pushing of one portion of a mineral, or rock-mass, over another, by intense pressure within the Earth's Crust.

Specific Gravity.—The ratio between the weight of a substance and that of an equal volume of water.

Slickensides.—A polished or striated surface caused by the rubbing together of rock masses within the Earth's Crust.

Spherulitic.—A nodular structure sometimes developed in certain volcanic rocks.

Stalactite.—Mineral matter, generally lime carbonate, suspended, icicle-like, from the roof of a cavity.

Stalagmite.—Mineral matter which has accumulated in pyramids on the floor beneath stalactites.

Streak.—The colour of the powder of a mineral.

Tuff.—A rock consisting of fragmentary material ejected from a volcano.

Twin Crystal. See page 55.

Vitreous.—Glass-like.

Vugh.—A cavity in an ore-body.

Wash-dirt.—That portion of an alluvial deposit that contains the mineral sought for.

The correct pronunciation of geological names is a matter of some difficulty to persons who have not had the advantage of trained tuition. The following hints may prove serviceable:—

ch in such words as *chalcedony*, *chiastolite*, *rhynchonella*, must be pronounced hard—that is, as if it were *k*. To pronounce it like *ch* in *church* is quite incorrect. *Chabasite* may be pronounced either way.

g in *gypsum*, *augi'e*, *plagioclase*. Custom varies. There is a tendency now to pronounce the *g* hard in all these words, and it is recommended that this should be done.

i in *crinoid*, *trilobite*. The English pronunciation as in *mite* is correct, and should be always followed.

a in the final syllable of *orthoclase*, *plagioclase*, *diabase*. It is customary in English for the vowel of a syllable ending in silent *e* to be lengthened, and this practice is usually followed in these words; thus *craze*, the *s* being pronounced as *z*.

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The names of mineral species are printed in SMALL CAPITALS.

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